Measuring Quality of Diabetes Care for Medicare Beneficiaries

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Shriram Parashuram

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Beth Virnig, PhD MPH

Advisor

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This dissertation is my sole work. But I was not in it by myself.

ABSTRACT

This dissertation consists of three papers studying existing practices in measuring quality of care for Medicare beneficiaries that warrant further examination. Quality of diabetes care is currently reported at the practice or plan level as a composite, summarizing multiple binary measures in the diabetes measure set. Medicare's Accountable Care Organization demonstration uses an all-or-none approach deeming only diabetics who receive all measures in the diabetes care measure set to have met the quality threshold. This approach while simple might not be as meaningful as a graduated approach. Other approaches to composite quality measurement, like Medicare's value based payment system for physicians, add up binary measures in the diabetes care measure set, weighting them equally. But all measures in the set might not be equally important for quality, making the case for weighting measures accordingly. Finally, Medicare's Physician Quality Reporting System (PQRS) offers incentive payments to physicians for reporting quality for their patients. In the absence of incentives for outcomes, the impact of reporting on outcomes is questionable.

The dissertation employs Medicare administrative claims to answer the above questions. Paper 1 compares prediction of subsequent outcomes for Medicare beneficiaries using all-or-none approach against a graduated approach to quality measurement. Paper 2 compares measure weights for diabetes care processes obtained using three alternate approaches to weighting composites, to study whether equal weighting is justified in practice. Paper 3 studies whether PQRS quality reporting for diabetics is linked to receipt of more recommended diabetes care processes and better outcomes.

The all-or-none approach all-or-none approach was found to discard meaningful important quality information, have poor discrimination and predictive validity. It was unsuited for the Medicare population as most diabetics did not receive all recommended care. Also, irrespective of how the quality construct was viewed, current practices of treating all process measures as equally important for ambulatory diabetes care were specious. Finally, PQRS reporting was associated with receipt of more recommended diabetes care processes. Reporting was also associated with greater guideline recommended pharmacotherapy and fewer avoidable hospitalization outcomes- through these processes. This dissertation ultimately emphasizes the need to better understand quality mechanisms to measure it appropriately for quality improvement.

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CHAPTER 1: INTRODUCTION

NATURE OF RESEARCH AND SIGNIFICANCE

The original research for this dissertation was motivated by current practices in measurement of quality of care for Medicare beneficiaries that warrant further examination. This dissertation uses diabetes care as an example to study issues surrounding quality measurement that are applicable to care for other chronic conditions as well.

Diabetes is one of the most prevalent chronic conditions in the United States. Twenty five percent of Medicare beneficiaries in 2011 suffered from diabetes [1]. The disease and its long-term complications- viz. cardiovascular disease, renal failure, cerebrovascular disease, lower-extremity amputations and blindness, place tremendous burden on the Medicare population, accounting for 32 percent of Medicare spending [2]. Given its prevalence, economic burden, and consensus around care elements, diabetes care has been at the forefront of quality measurement efforts for almost two decades. Apart from long being incorporated as measures of Medicare plan quality through Healthcare Effectiveness Data and Information set (HEDIS), diabetes care quality measures have more recently been adopted by the Centers for Medicare and Medicaid Services (CMS) for use at the physician and group practice levels with programs such as Medicare's Physician Quality Reporting System (PQRS) and Accountable Care Organization (ACO) demonstrations [3-5].

Quality of diabetes care is reported currently at the plan, physician or ACO level as a summary composite that combines criterion measures for diabetes care by weighting them

equally. The Medicare ACO demonstration uses an all-or-none rule, deeming only diabetics who receive all measures in the diabetes care measure set to have received quality diabetes care[5]. This approach is questionable if diabetics who get fewer measures have the same outcomes as those who get all, or if diabetics who get some measures do better than those who get none. Medicare's value-based payment system for physicians to be implemented in 2015, considers each of the four process measures in its diabetes composite to be equally important for quality[6]. However all process measures in the composite may not be equally important for diabetes care. Finally, with more thrust placed on physician reporting of diabetes care quality measures through payments and penalties [3], it is worthy to examine whether quality reporting for diabetics is linked to better outcomes and more conscientious ambulatory care.

SPECIFIC AIMS

This dissertation makes important contributions to measurement of quality of diabetes care for Medicare beneficiaries. It consists of three separately publishable manuscripts. The first paper contrasts the all-or-none approach with a graduated approach to measuring quality of diabetes care for Medicare beneficiaries, to examine the predictive validity of the former with respect to hospitalization outcomes. The second paper compares measure weights for diabetes care processes obtained from three alternate approaches for developing weighted composites for diabetes care quality, to study whether equal weighting of these process measures is justified in practice. In the third paper, we study whether PQRS quality reporting for diabetics is linked to receipt of more recommended diabetes care processes, better guideline recommended pharmacotherapy & hospitalization outcomes, and more conscientious ambulatory care.

CHAPTER 2: BACKGROUND

In this chapter, background and literature on diabetes and standards of care for diabetes are first reviewed. Thereafter the chapter reviews background and literature on quality measurement both in the general context and in the context of diabetes care. The review helps develop the methodology and conceptual framework for the research papers presented three subsequent chapters.

DIABETES

CLASSIFICATION, PREVALENCE AND BURDEN

Diabetes is a group of chronic clinical conditions characterized by hyperglycemia. The classification of diabetes includes four clinical classes: 1) type 1 diabetes 2) type 2 diabetes 3) gestational diabetes mellitus 4) other specific types of diabetes due to other causes, e.g. genetic, drug or chemical [7]. This focus of this dissertation is type 1 and type 2 diabetes.

According to the CDC , the total number of individuals reported to have diabetes in the United States has more than tripled from 5.8 million in 1980 to 18.8 million in 2010 [8]. The disease is prevalent in the elderly Medicare population. In 2011, the prevalence of diabetes in the Medicare population was 25% [1]. Diabetes prevalence varies with age, gender and race/ethnicity. The prevalence of diabetes increases with age (highest in age of 60 years and above) and more likely to occur in men. Diabetes is at least 2 to 4 times prevalent among non-Hispanic Black, and Hispanic/Latino Americans than non-Hispanic whites [8].

Diabetes poses an immense economic burden on the healthcare system. The total annual cost of diabetes was estimated to be $174 billion in 2007. The direct medical expenditures accounted for $116 billion out of which $29.3 billion was spent for diabetes care, $31.1 billion for chronic diabetes-related complications, and $55.7 billion for an excess prevalence of general medical conditions. Indirect costs associated with diabetes totaled $58 billion, mainly resulting from the lost workdays, restricted activity days, mortality, and permanent disability. Individuals age 65 or older bore the majority of the estimated costs at $60.1 billion [8]. According to CMS, 32% of Medicare spending can be attributed beneficiaries with diabetes [2].

COMORBIDITIES AND COMPLICATIONS OF DIABETES

Hypertension is the most common comorbidity associated with diabetes, with the two conditions being mutual reinforces. More than 60-70% of people with diabetes have hypertension. The prevalence of hypertension is three times higher in diabetics than non-diabetics [7, 8]. Hypertension is a risk factor for complications of diabetes, and control of hypertension is hence an integral part of managing diabetes [7].

The complications of hyperglycemia in diabetes can be classified into three types: (1) short-term complications (2) microvascular complications (3) macrovascular complications.

Short-term complications

Hypoglycemia, Diabetic ketoacidosis (DKA), hyperosmolar hyperglycemic state (HHS) and uncontrolled hypertension are the four acute metabolic complications of diabetes resulting in ER visits and hospitalizations related to diabetes. These complications

can occur in both type 1 and type 2 diabetes, but are more likely to occur in diabetics taking insulin.

Micro and macrovascular complications of diabetes are a result of disease progression over a much longer time frame (>5-10 years) [9].

Microvascular complications:

Diabetic Retinopathy: Diabetic retinopathy is the most common microvascular complication of diabetes and is responsible for approximately 100,000 new cases of blindness annually in the United States [10]. The risk of developing retinopathy and other microvascular complications of diabetes depends on both severity & duration of hyperglycemia, as well as hypertension, as shown in the U.K Prospective Diabetes Study (UKPDS) [7]. Retinopathy is estimated to take at least 5 years to develop after the onset of diabetes [11].

***Diabetic Nephropathy*:** Diabetic nephropathy is the leading cause of chronic kidney disease (CKD) and end-stage renal disease (ESRD, i.e. the fifth and final stage of CKD) in the United States [11]. Nephropathy is characterized by macroalbuminuria, i.e. proteinuria > 300mg in 24 hours; and is preceded by microalbuminuira. Like other microvascular complications of diabetes, there are strong associations between glycemic control and the risk of developing diabetic nephropathy[8].

***Diabetic Neuropathy*:** Diabetic neuropathy is characterized by presence of symptoms and/or signs of peripheral nerve dysfunction in people with diabetes after the exclusion of other causes [7]. Amputation and foot ulceration resulting from diabetic neuropathy and/or peripheral artery disease are common and major causes for morbidity and disability in people with diabetes [8]

Macrovascular Complications:

***Cardiovascular Disease*:** Diabetes increases the risk of cardiovascular disease (CVD) in individuals. [12, 13]. CVD also accounts for the greatest component of health care expenditures in people with diabetes [14]. Microvascular manifestations of diabetes are additional risk factors for coronary events [15].

***Stroke*:** Diabetes is also an important independent predictor of stroke and cerebrovascular disease. The risk of stroke can be as high as 150-400% in people with type 2 diabetes compared to non-diabetics [9]. Stroke is the leading cause of disability and the third leading cause of death among persons with diabetes [16].

***Peripheral Vascular Disease*:** Peripheral artery disease (PAD) along with neuropathy is a major risk factor for lower extremity amputations in diabetics[11]. PAD is also a marker for CVD. 30% of diabetics with PAD have lower extremity amputations and 20% die within 6 months of having the disease[7].

STANDARDS OF CARE FOR DIABETES

The first evidence-based standards of care for persons with diabetes were published by the American Diabetes Association (ADA) in 1988. Since, ADA has regularly revised and published guidelines for the care of diabetics [17]. The guidelines recommend the following to providers treating diabetics:

Glycemic Control and Assessment with HbA1C Testing: The assessment of glycemic control is to be continually done by the provider by measurement of hemoglobin A1C (HbA1C or A1C). ADA recommends that HbA1C testing be done at least twice a year in patients who meet treatment goals and quarterly in patients whose therapy has changed or

are not meeting treatment goals [17]. HbA1C levels >9% reflect poor glycemic control and HbA1C levels at or below 7% reflect good glycemic control, and the ADA recommends the latter goal in diabetics <65 years of age. ADA however recognizes that less stringent A1C goals may be appropriate for patients with a history of severe hypoglycemia, limited life expectancy, advanced microvascular or macrovascular conditions, extensive comorbid conditions etc. Epidemiological studies and meta-analyses have shown a direct relationship between A1C and CVD, but the potential of intensive glycemic control to reduce CVD is less clearly defined [17]. Clinical guidelines in the last decade moved the good glycemic control threshold to <8%, due to findings from clinical trials that have shown increased risk of mortality among diabetics with aggressive glycemic control. More recent clinical guidelines recommend individualizing 'good' HbA1c goals for patients [17]. Pharmacotherapy with insulin or oral antidiabetic (OAD) medications should be used to achieve the goals of glycemic control [17].

Control and Measurement of Hypertension: ADA recommends that blood pressure be measured at every routine diabetes visit and that patients be treated to achieve systolic blood pressure <130 mmHg and diastolic pressure <80 mmHg. Pharmacotherapy using Angiotensin Converting Enzyme (ACE) Inhibitors or Angiotensin Receptor Blockers (ARBs) are recommended to control blood pressure in patients who have systolic pressure ≥140 mmHg or diastolic pressure ≥90 mmHg [17].β blockers, diuretics and calcium channel blockers may also be used in addition to achieve blood pressure targets or where ACE inhibitors and ARBs are contraindicated. Results from clinical trials have shown that lowering blood pressure to the recommended goals in individuals with diabetes was associated with reduction of CHD events, stroke and nephropathy[17].

Control and Measurement of Dyslipidemia: ADA recommends that lipid profile for adults with diabetes be measured at least annually[17]. The goal of lipid management is to keep levels of LDL cholesterol <100 mg/dl in diabetics without overt CVD, or <70mg/dl in diabetics with overt CVD on pharmacotherapy. Diabetics with overt CVD and those over the age of 40 with one or more CVD risk factors are recommended statin therapy. In other diabetics statin therapy may be considered. Multiple trials have demonstrated the effect of statin therapy on CVD outcomes in subjects with coronary heart disease. Sub analyses of diabetic subgroups in these trials, as well as clinical trials with diabetic subjects, have shown significant primary and secondary prevention of CVD events in diabetic population with statin therapy[17].

Nephropathy screening and treatment: Apart from optimizing glucose control and blood pressure control, ADA recommends annual screening for microalbuminuria to prevent nephropathy. An annual test to assess urine albumin excretion is advised in all type 2 diabetes patients starting at diagnosis and in all type 1 diabetes patients with diabetes duration of 5 years or more[17]. Annual measurement of serum creatinine in the urine is also recommended in diabetics to stage the level of chronic kidney disease. Diabetics with micro- or macroalbuminuria are to be treated with ACE inhibitors or ARBs[17].

Retinopathy screening and treatment: Annual dilated eye examination by an ophthalmologist or optometrist is recommended for preventing diabetic retinopathy, along with control of glycemia and blood pressure [17]. Patients with any level of macular edema, severe NPDR or PDR should be referred to an ophthalmologist for laser photocoagulation therapy[17].

Prevention of cardiovascular disease using antiplatelet agents: Aspirin therapy (75-162 mg/day) is recommended as a primary prevention strategy in those with type 1 or type 2 diabetes with cardiovascular risk factors. Aspirin therapy is also recommended as a secondary prevention strategy in diabetics with CVD[17]. One large meta-analysis and several clinical trials have shown the efficacy of aspirin therapy as a preventive measure for cardiovascular and cerebrovascular events, including AMI and stoke[17].

Smoking Cessation: Studies on diabetics have found a heightened risk of CVD and premature deaths among smokers. Hence ADA recommends that smoking cessation counseling and treatment be included as a routine component of diabetes care[17]. The smoking status of diabetics should be assessed and they should be advised to stop smoking. A large number of randomized trials have demonstrated the efficacy of smoking cessation counseling on altering smoking behavior and reducing tobacco use[17].

Neuropathy screening and treatment: ADA recommends that all diabetics should be screened for distal symmetric polyneuropathy (DPN) at diagnosis and annually thereafter, using simple tests. Patients with DPN should aim for glycemic control and may benefit from pharmacological treatment for their symptoms [17].

Foot Care: All patients with diabetes are required to have a comprehensive annual foot examination to identify risk factors for foot ulcers and amputations. The risk of ulcers and amputations is higher for diabetics with previous amputation, past foot ulcer history, peripheral neuropathy, PAD, foot deformity, retinopathy, nephropathy, poor glycemic control and cigarette smoking. Patients should also be educated on appropriate foot care and its implications[17].

Diabetes Education Programs: Diabetes education programs recommended by ADA include Medical Nutrition Therapy (MNT) and Diabetes Self-management Education (DSME). ADA recommends that individuals with diabetes receive individualized MNT provided by a dietician, as needed, to achieve treatment goals. ADA also recommends diabetics receive DSME according to national standards upon diagnosis and as needed thereafter. DSME helps diabetics undertake effective self-care when they are first diagnosed, while follow-up DSME helps them maintain effective self-management as the disease presents new challenges and treatments[17].

Other Preventive Care: ADA recommends annual influenza vaccination for all diabetics 6 months of age or older, and a lifetime pneumococcal vaccine for those 2 years of age or older. A one-time revaccination of the pneumococcal vaccine is recommended for elderly diabetics if they were immunized previously when they were less than 65 years and the vaccine was administered 5 or more years ago[17].

QUALITY MEASUREMENT

According to Institute of Medicine (IOM), healthcare should aim to be safe, effective, patient-centered, timely, efficient and equitable[18]. Keeping with these six aims, health quality can be measured at four different hierarchical levels: (1) patients, (2) physician microsystems, (3) organizations that house physician microsystems, or (4) the macrosystem in which organizations are nested [18]. While the level of the patient remains the fundamental level of quality measurement, quality at each level is measured as structures, processes or outcomes, as proposed by Donabedian [19]. The IOM's well accepted definition of quality of care - "the degree to which health services for individuals

or populations increase the likelihood of desired health outcomes and are consistent with current professional knowledge" [20], recognizes that quality at the patient level can be measured either as desired health outcomes or as adherence to processes proven by scientific evidence [21].

PROCESS VERSUS OUTCOME MEASURES IN QUALITY MEASUREMENT

Outcomes are the 'bottom-line' of quality of care. Patients and providers both care about outcomes of care. Process measures have little value unless they are linked to outcomes; however that link is often difficult to demonstrate. Clinicians tend not to prefer outcome measures as differences in outcomes are influenced by factors other than the quality of care such as differences in patient type, differences in measurement and random variation[22]. Comparison of outcome measures hence requires exhaustive risk adjustment. While intermediate outcomes may be obtained from shorter periods of observation (1-2 years), terminal outcome measures are rarer and require longer periods of observation (5-10 years) and concomitantly larger patient samples. Intermediate and terminal outcome measures are also not easily obtained from administrative data [22].

Process measures have been increasingly used in quality measurement due to their advantages over outcome measures. Process measures have the advantage of being actionable, i.e. they identify what is being done well and what needs improvement. While differences in outcomes can be attributed to factors other than differences quality of care, process measures are more sensitive to quality of care. Process measures are easy to measure using administrative data, they have face validity and can be easily interpreted by clinicians - as most of them directly measure quality, and they do not require exhaustive risk adjustment as long as the eligible population is clearly defined [22]. However, in order

to be valid, process measures need to be strongly linked to outcomes Apart from clear definition of the eligible population, process measures need to be constantly reviewed and updated according to advances in treatment. Feasible process measures measure only specific aspects of quality of care for a disease. The comprehensive measurement of quality of care for a disease requires multiple process measures that measure all aspects of care for that disease [22].

QUALITY COMPOSITES

As multiple process measures are considered for measuring quality of care for a disease in value based purchasing initiatives, it becomes challenging to ascertain the value of specific process and compare providers or plans accordingly. In such cases, measures of quality from different domains of care for the disease can be combined into one summary composite quality measure. Composite process measures offer four advantages over unaggregated measures [23]. Firstly, they provide an overall summary of quality of care, facilitating easy comparison of quality at the patient, provider or plan level. E.g. NCQA has used a single composite measure of diabetes care to compare plans by combining rates of 4 process measures viz. HbA1c testing, LDL-C testing, eye exam and medical attention to nephropathy at the plan level [24]. Standardized composite measures allow the ranking of providers and plans by overall quality score. Composite measures, based on the method of their weighting, may provide a 'fairer' method of comparing clinical performance as there would be many ways for providers or plans to get a good overall composite score. Finally, composite quality measures have higher reliability than unaggregated measures, and hence allow for comparison of smaller sample sizes of patients, providers or plans. Composite measures also have their disadvantages [23]. They are harder to interpret and are less

actionable for quality improvement than unaggregated measures. Composite measures are more difficult to validate than individual measures. There is a lot of debate on what individual process measures should be included in a composite and how they should be combined to create the composite.

There are three steps commonly used to create quality composites from individual measures [23]. The first step is the sampling of individual measures of quality of care from the domain of observables. The measures chosen should have a direct hypothesized relationship to the construct, based either on clinical evidence or sound conceptual reasoning. The second step is ensuring that the individual measures are transformed to metrics that allow them to be combined to a composite. Items with different metrics can be combined by using standardized z-scores or standardization using scoring range. Finally, individual items included in the composite should be alterable to provider attempts to improve quality. Measures that are independent of the quality of care provided and depend solely on patient or regional characteristics should not be included in the composite[23].

The individual items can be combined in a variety of ways to create the composite as shown in Table 2.1 below [23]. All these methods weight the individual measures equally. Reeves et al (2007) compared 5 different composite scoring methods- 'All-or-none', '70% Standard', 'Overall Percentage', 'Indicator Average' and 'Patient Average', to rank primary care physician practices using two patient data sets, the first with acute, preventive and chronic measures, and the second with only chronic measures. They found that the different scoring methods produced different physician practice rankings and a third of the practices moved between the top and bottom quartiles depending on the scoring method used[25].

The variation in scores was lesser in the data set with chronic measures. Criterion based scoring methods like 'All-or-none' & '70% Standard' dichotomized composite quality. The case for these scoring methods was strongest only when all individual quality indicators were equally important clinically, which is not the case in practice[25]. 'Overall Percentage' and 'Patient average' are best used for homogenous populations as common indicators swamp them more than less common ones. 'Indicator average' which provides an average measure of quality across processes of care is best for heterogeneous populations and measures. 'Patient averages' which give composite quality scores for patients as well as the entire sample provide analytic advantage over other composites[25]. However these methods simply combine individual measures into composites, without weighting them based on their relative importance. The next section discusses the theory and methods for creating weighted composites.

Table 2.1: Alternative Scoring Methods to Create Composites by Equal Weighting of Measures [25].

Scoring Method used to Create Composite	**Description of Scoring Method**	**Example (*Combination of Individual Item Scores= Composite Score*)**
i) Linear Scoring	The composite is a linear combination of the individual items. Linear scores reported as overall percentages providing a measure of ***average quality across opportunities of care***.	CMS Hospital Compare *1, 1, 1=3* *1,0,1 = 2* *0,0, 1= 1*

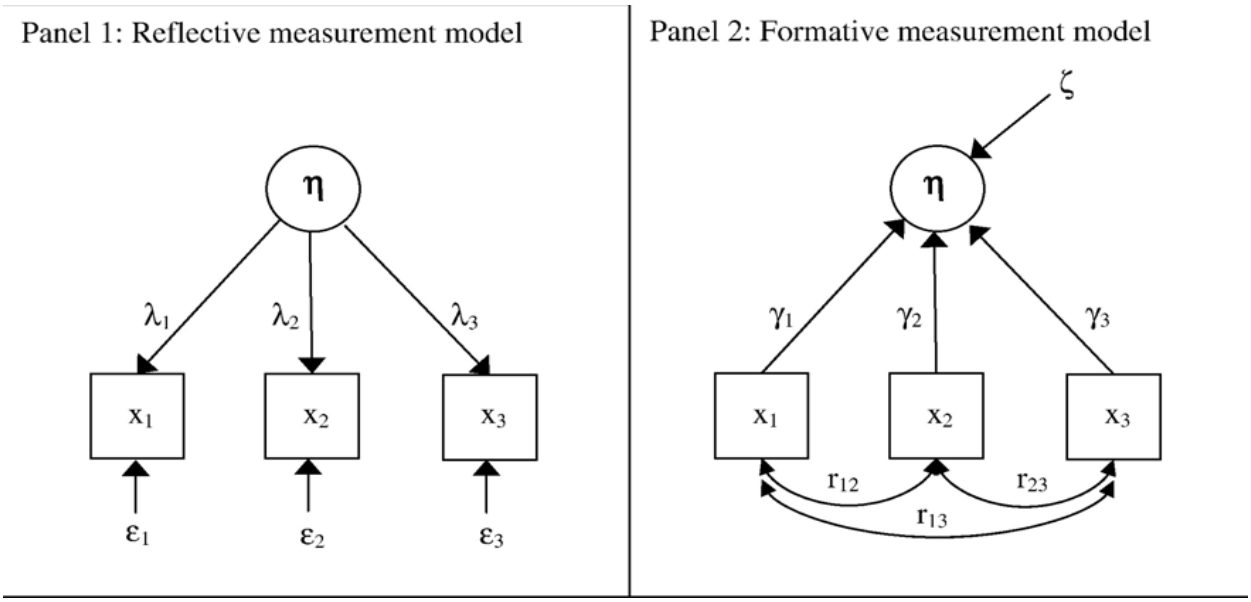
Scoring Method used to Create Composite	Description of Scoring Method	Example (***Combination of Individual Item Scores= Composite Score***)
ii) All-or-None or Multiplicative Scoring	The composite has a 'successful' score only when all individual items have successful scores.	Medicare ACO Demonstration *1,1,1=1* *1,0,1=0* *0,0,1=0*
iii) Opportunity Scores	**Indicator Averages** or **Patient Averages**. Indicator averages created by dividing the number of eligible patients who receive recommended care for each measure by the number of eligible patients. Opportunity scores for individual measures are then averaged to create the ***indicator average composite, which provides a measure of average quality across processes of care***. Opportunity scores can also be created as patient averages, i.e. the care opportunities that were met for each patient, providing a measure of ***average quality of care provided to a sample of patients.***	Medicare's Physician Value-based Payment System & HEDIS Comprehensive Diabetes Care composite (reported at the plan level) *300/1000, 400/1000, 500/1000= 0.4*

Approaches to Creating Weighted Quality Composites

Most scoring methods for combining individual measures into composites are ad hoc, as they pay little or almost no theoretical attention to what is being measured. The methods used to create weighted composite scores should be based on theory. Health care

quality can be viewed as an 'unobserved' construct or a latent variable. The only variables that we observe, i.e. process or outcome measures, are either 'reflective' or 'formative' of this construct (Figure 2.1) [26].

Figure 2.1: Reflective and Formative Measurement Models [27]



A construct exists independent of its reflective measures. The observed measures are merely manifestations or effects of a reflective construct. The direction of causation here is from the unobserved construct (or latent variable), healthcare quality, to its measures -processes and outcomes. If observed measures of healthcare quality are indeed effect measures, we would expect all process and outcome measures to be positively intercorrelated as they share a common latent cause. Any variation in quality of care should cause variation in all of the observed process and outcome measures. In a reflective model, health care quality, η, is viewed as a common cause shared by all observed effect measures

x_i of the construct, where each measure is a linear function of the construct plus measurement error [27].

$$x_i = \lambda_i \eta + \varepsilon_i$$

where, x_i is the ith measure of the latent variable η, ε_i is the measurement error for the ith indicator, and λ_i is a coefficient (loading) capturing the effect of η on x_i. Measurement errors are assumed to be independent (i.e., $\text{cov}(\varepsilon_i, \varepsilon_j)=0$, for $i \neq j$) and unrelated to the latent variable (i.e., $\text{cov}(\eta, \varepsilon_i)=0$, for all i).

A construct is defined by its formative measures. In this case, observed measures – process and outcomes would be viewed as causes of the formative construct- healthcare quality. Formative measures may be correlated with one another however they need not be. Each formative measure, process or outcome, captures a specific aspect of the domain of healthcare quality, and omitting a measure alters the nature of the construct. According to the formative model, health care quality, η, would be:

$$\eta = \sum_{i=1}^{n} \gamma_i x_i + \zeta$$

where, γ_i is a coefficient capturing the effect of measure x_i on the latent variable η, and ζ is a disturbance term. The disturbance term, specified at the construct level, comprises all remaining causes of the construct which are not represented by the measures and are not correlated to the latter; thus following the assumption that $\text{cov}(x_i, \zeta)=0$ [27].

Consider the case of the construct "quality culture in a health plan". The health plan's quality culture could be viewed as a reflective construct that manifests in the form of

the plan's process measure scores and health outcomes for plan members. Else the quality culture in plan can be viewed as a formative construct caused by the plan's adherence to process measures and performance on health outcomes for its members [28].

The method of developing a composite measure of healthcare quality would depend on whether the observed measures were viewed as reflective (effects) or formative (causes) of the latent construct. Reflective measurement models, employed extensively in psychology and social sciences, use methods like factor analysis and latent variable modeling that identify the underlying construct based on correlations between the observed measures and **scale** them into a composite measure. Since reflective indicators are expected to have a high correlation, the reliability of composite measures can be assessed empirically with measures such as factor loadings, communalities, and Cronbach's alpha. In formative measurement models, the individual measures would be weighted to create a **composite index** of healthcare quality, based on the relative importance of the measures for quality. The weights can be obtained either empirically or using expert opinion.

According to Wilcox et al (2008), constructs by themselves are neither reflective nor formative; however researchers may choose to view them as either, based on the items that are used to measure the construct and their relation to the construct, to each other, as well as to the construct's antecedents and consequences [29].

A review of the literature, summarized in Table 2.2 below shows that researchers have viewed constructs like health plan quality as reflective constructs and hospital quality as formative constructs. The formative view of quality in hospitals has been motivated by

the different domains of quality that hospital process measures capture, as well as the poor correlation among hospital process measures.

Table 2.2 Approaches Chosen for Weighting Quality Composites in Health Services Research Studies

Author (Year)	Composite Construct (Reflective/Formative) and method of estimation	Observed Measures	Reason for Reflective/Formative Model Choice
Shwartz et al (2008)[30]	**Hospital Quality Composite** (**Reflective**) using weights from a Bayesian latent variable model for hospital level process measures based on the correlation between measures	Hospital level process measures for AMI, CHF and Pneumonia from the hospital compare database	• Correlation between process measures
Staiger et al (2009)[31]	Composite measure of **Surgical Performance in Hospitals** (**Formative)** using hospital level surgical performance measures. Weights for these measures were **empirically derived** based on how they predicted hospital level surgical mortality	Hospital level performance measures for Aortic Valve Replacement and related surgeries	• Surgical performance measures at the hospital level predicted mortality • Surgical performance measures captured different dimensions of hospital surgical performance
Glickman et al	Composite measure of	Hospital level	• Process measures

Author (Year)	Composite Construct (Reflective/Formative) and method of estimation	Observed Measures	Reason for Reflective/Formative Model Choice
(2009)[32]	**Process-measure Adherence in Hospitals (Formative)** created using weights from **principal component analysis** of CMS hospital level process measures	process measures for AMI and CHF and Pneumonia from the hospital compare database	are a reflection of how hospitals operate and provide care. Process measures that capture different dimensions of hospital quality load on different factors.
Caldis (2007) [33], Leid et al (2002)[34]	A scale for **Health Plan Quality (Reflective)** from **factor analysis** of HEDIS measures	Plan rates for 31 [33] and 17 [34] HEDIS process and outcome measures	• HEDIS measures are an effect of plan quality of care • High correlation between certain HEDIS measures at the plan level
Zaslavsky et al (2002)[35]	Four composite scores summarizing **Health Plan Quality (Reflective)** from **factor analysis** of HEDIS measures and CAHPS survey results	Plan rates for 8 HEDIS and 12 CAHPS quality of care measures	• HEDIS and CAHPS measures are reflective of plan quality of care • High correlation between certain HEDIS & CAHPS measures at the plan level

In the reflective measurement model the underlying construct is identified using factor analysis, based on the observed correlation between measures. Factor scores can then be used to weight individual measures. In the formative measurement model, individual measures can be weighted empirically or using expert opinion. The empirical weighting of measures using formative measurement models is methodologically challenging, especially if there is multicollinearity between observed measures. The problem with empirical formative model identification using structural equation modeling is well documented and has resulted in their criticism[27]. Weights for measures in formative measurement models can be otherwise assigned using an expert panel, i.e. a panel of physicians can be asked to weight individual process measures based on their relative importance. However, if we assume the observed measures to be independent, then the measures can be empirically weighted based on their association with subsequent patient outcomes. In Chapter 4 we employ factor weighting, physician weighting and outcomes-based empirical weighting to weight diabetes care measures for creating quality of diabetes care composites.

QUALITY MEASUREMENT FOR DIABETES CARE

Diabetes care has been at the center of quality measurement initiatives, since the first national effort to develop a set of performance measures for the disease was convened by the CMS, the National Committee on Quality Assurance (NCQA), and the ADA in 1995. The Diabetes Quality Improvement Program (DQIP) developed a set of eight binary process and intermediate outcome measures that were based on either evidence from clinical trials or consensus[36] . As these measures could be readily obtained from healthcare claims or

medical records, and their periodic measurement was appropriate for all patients with the exception of the very elderly- they were adopted by NCQA as HEDIS measures and widely used to assess diabetes care performance of Medicare, Medicaid and commercial health plans [4]. The last fifteen years have seen an increase in the rates of these recommended diabetes care measures among diabetics in the US. Even as the performance of these measures has improved, there has been a concurrent reduction in rates of adverse outcomes such as renal failure and LEA in the diabetic population [37-39].

Review Of Literature On Quality Of Diabetes Care And Patient Outcomes

Studies investigating the effect of quality of diabetes care on diabetic outcomes have usually examined the effect of process measures on intermediate outcomes (e.g. HbA1c testing on HbA1c level), process measures on terminal outcomes (e.g. HbA1c testing on micro or macro vascular complications), or intermediate outcomes on terminal outcomes (e.g. HbA1c level on incidence of cardiovascular disease) [40]. A systematic review of twenty four such studies showed that (i) improvements in processes of care like HbA1c and blood pressure measurement did not really result in improvement in intermediate outcomes, viz. better control of HbA1c and blood pressure; (ii) more processes of care, e.g. more HbA1c tests, were associated with poorer terminal outcomes like hospitalizations for metabolic events due to confounding with severity of diabetes; (iii) studies that demonstrated an association between better intermediate outcomes and better terminal outcomes did not adequately risk-adjust for patient factors that were associated with poor intermediate and terminal outcomes [40]. The terminal outcomes chosen in these twenty four studies were health status; hospitalizations for metabolic, micro vascular, and macro

vascular complications, cardiovascular events, heart and kidney disease, and amputations ;and death[40]. Attributing outcomes such as micro or macro vascular complications that are the consequence of multiple years of diabetes progression (>5-10 years) to quality of diabetes care in a short time frame (0-2 years) is dubious [9]. None of these studies adequately adjusted for duration of diabetes, which is more important than merely adjusting for age. Finally, none of these studies looked at the effect of ambulatory diabetes care measures on subsequent hospitalizations for a set of ambulatory care sensitive conditions associated with diabetes (diabetes ACSCs), viz. uncontrolled diabetes, complications of diabetes, hypoglycemia and hypertension [40, 41].

In this dissertation, we address the limitations of previous studies by studying the effect of ambulatory diabetes care measures on hospitalizations for diabetes ACSCs. To study if diabetes care measures also have an effect on overall ambulatory care, we examine the effect of these measures on subsequent hospitalizations for all ACSCs[41].

CHAPTER 3: QUALITY OF AMBULATORY DIABETES CARE FOR MEDICARE BENEFICIARIES: A CRITIQUE OF THE "ALL-OR-NONE" APPROACH TO QUALITY MEASUREMENT

Objective: To examine the predictive validity of the all-or-none approach for measuring the quality of ambulatory diabetes care for fee-for-service Medicare beneficiaries, we studied whether beneficiaries who receive 'all ' and 'not-all ' scores for a set of four claims computable diabetes process measures, viz. annual HbA1c testing, annual LDL cholesterol testing, annual dilated eye examination and, annual testing for diabetic nephropathy, differed in their likelihood of hospitalizations related to ambulatory diabetes care and ambulatory care in the subsequent year.

Data and Methods: A retrospective cohort study design following a 5 percent nationally representative sample of 194,345 fee-for-service Medicare beneficiaries with diabetes aged 18-75 years in 2006, who were alive at the end of 2007. We used multivariate logistic regression to examine the association between number of diabetes process measures in 2006 and likelihood of hospitalizations for ambulatory care sensitive conditions associated with diabetes (diabetes ACSCs) and all ambulatory care sensitive conditions (ACSCs) in 2007. For beneficiaries who received one, two or three of the four diabetes process measures we employed stratified multivariate logistic regressions to examine the association between type of diabetes process measures in the prior year and likelihood of hospitalization for diabetes ACSCs and all ACSCs in the subsequent year.

Results: *There was no difference in the likelihood of diabetes ACSCs or all ACSCs between beneficiaries who received three and four process measures, even though the all-or-none approach views them to be diametrically different with respect to quality. Beneficiaries who received one, two or three process measures had a significantly lower risk of hospitalizations for diabetes ACSCs and ACSCs compared to beneficiaries who received no process measures - even though the all-or-none approach views these beneficiaries to have received the same quality of diabetes care. Beneficiaries who did not receive either HbA1c testing or LDLC testing had a significantly higher likelihood of either hospitalization compared to other beneficiaries who received at least two process measures.*

Conclusion: *The all-or-none approach to quality measurement has poor predictive validity, discards important quality information and has poor discrimination. It is not suited for the Medicare population, nor is it ideal for diseases where multiple measures vary in their relative importance.*

INTRODUCTION

More than twenty-five percent of Medicare beneficiaries suffer from diabetes. Annual healthcare expenditures for these beneficiaries are two and half times greater than those without the disease [14]. Given its prevalence, economic burden, and consensus around care elements, diabetes care has been at the forefront of quality measurement efforts for almost two decades- since the first set of quality measures for the disease was developed by the National Committee on Quality Assurance (NCQA) to measure health plan performance in 1995 [36].

Over the years, these quality measures for diabetes have been used in a binary format for process (done/not) and intermediate outcome measures (above/below threshold value)[1][4]. These criterion measures are often combined together by addition, to obtain a composite measure that provides a summary of the quality of ambulatory diabetes care provided by physicians or health plans. Recently, there has been movement towards adopting an all-or-none approach (second level of binary), where binary process and/or intermediate outcome measures are combined into a single 0-1 composite score by multiplication. In this approach, credit is given only when all discrete elements of care are provided, in contrast to the traditional approach that gives partial credit when at least some of the elements of care are provided [42]. Developed first by Health Partners, the all-or-none approach is used by Minnesota Community Measurement for measuring quality of diabetes care[2] provided by 300 medical clinics in the state[43]. The Center for Medicare and Medicaid Services' Accountable Care Organization (ACO) demonstration has also adopted the all-or-none approach to measure quality of care provided by group practices for diabetes and coronary artery disease[5].

The all-or-none approach has some advantages in that it is easy to implement as it treats all elements of care as equally important, and allows more opportunity for quality

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[1] Process measures include annual Hemoglobin A1c (HbA1c) testing, annual low density lipoprotein cholesterol (LDLC) testing, annual dilated eye exam, and medical attention for nephropathy. Intermediate outcome measures include blood pressure control (<140/90 mmHg), HbA1c control (<9%), LDLC control (<130 mg/dL)

[2] *Minnesota Community Measurement's D5 measure for diabetes gives a clinic credit only when it meets all five treatment goals for the diabetic patient, viz. blood pressure less than 140/90 mmHg, LDL Cholesterol less than 100mg/dl, HbA1c of less than 8%, tobacco cessation and daily use of Aspirin.*

improvement by setting the bar high [42]. However, the approach falls short if it combines criterion measures where some measures in the set are more important than others, say with respect to quality of care measured as patient outcomes [4]. In the case of ambulatory diabetes care, some process measures could be more important than others in preventing subsequent patient outcomes such as hospitalizations for ambulatory care sensitive conditions associated with diabetes. The all-or-none approach also has lesser discrimination than the equally simple additive approach. It ignores the different levels of quality that truly exists among beneficiaries who do not get all measures[4]. This problem is especially amplified in the older Medicare population where the majority of beneficiaries do not receive all recommended ambulatory diabetes care measures.

This paper tests the predictive validity of the all-or-none approach for measuring the quality of ambulatory diabetes care for fee-for-service Medicare beneficiaries. We compare the likelihood of ambulatory diabetes care-related outcomes in the subsequent year for beneficiaries who receive 'all ' and 'not-all ' scores for a set of four claims-computable diabetes process measures: (i) annual HbA1c testing, (ii) annual LDL cholesterol testing, (iii) annual dilated eye examination and, (iv) annual testing for diabetic nephropathy. We specifically compare the likelihood of hospitalizations for ambulatory care sensitive conditions associated with diabetes (diabetes ACSCs) and for all ambulatory care sensitive conditions (all ACSCs) in the subsequent year among Medicare beneficiaries (aged 75 or younger) who receive none, one, two, three or all of the ambulatory diabetes care measures in the prior year. Better ambulatory care has been shown to lower the rate of ACSCs [45-47]. We also examine whether some of the ambulatory diabetes care process

measures are more important than others in predicting the risk of avoidable hospitalizations in the subsequent year.

METHODS

DATA

This study employed data from the 2006 and 2007 Chronic Condition Data Warehouse (CCW) 5% Medicare files. Specifically, we used beneficiary summary, inpatient, outpatient, and carrier claims (physician and durable medical equipment) for a 5 percent random sample of Medicare beneficiaries. We also used Small Area income and education data sets from the Census Bureau. Our study sample consisted of Medicare fee-for service beneficiaries with diabetes, who were alive at the end of 2007. Beneficiaries were continuously enrolled in Part A (coverage for hospital care) and Part B (coverage for physician care), with no months of managed care enrollment for either year. We identified beneficiaries with diabetes using the chronic condition flag for the disease [48]. We applied additional restrictions so that our sample met the HEDIS denominator definitions for quality : we excluded beneficiaries older than 75 years in 2006 and, those with HIV, active cancer treatment, organ transplant and end-stage-renal disease (see Appendix 1 for exclusion codes) [44]. The final study cohort consisted of 194,345 beneficiaries

MEASURES

We used CPT codes to identify beneficiaries who received the following diabetes process measures in 2006 from their carrier and outpatient claims: (i) annual HbA1c testing

(ii) annual LDLC testing (iii) annual dilated eye exams [3], and (iv) testing for nephropathy[4].The definitions of these measures and the codes used to identify them from claims are summarized in Appendix 2. The four diabetes process measures are claims computable HEDIS diabetes measures that have long been used to measure quality of diabetes care in health plans, and more recently for physicians.

OUTCOMES OF INTEREST

We chose two avoidable hospitalization outcomes in the subsequent beneficiary year that should be closely tied to quality of ambulatory care for diabetes:

(i) Hospitalizations for ambulatory care sensitive conditions associated with diabetes (diabetes ACSCs): These were hospitalizations for complications of diabetes, uncontrolled diabetes, hypoglycemia, and hypertension [41].

(b) Hospitalization for all ambulatory care sensitive conditions (ACSCs): These are a larger set of hospitalizations, defined by the Agency for Healthcare Research and Quality, that can be avoided by better ambulatory care (all ACSCs) [41].

We identified hospitalizations for diabetes ACSCs and all ACSCs in 2007 from inpatient hospital claims (see Appendix 3 for the list of conditions and diagnosis codes for diabetes ACSCs and all ACSCs).

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[3] *The HEDIS measure set counts any E&M visit to an Ophthalmologist or Optometrist as an eye exam. We use a more conservative definition of the process measure to include only dilated retinal exams.*

[4] *The HEDIS measure set defines attention for nephropathy as documentation of nephropathy or testing for nephropathy. We define the process measure to include only testing for nephropathy.*

STATISTICS

We obtained descriptive statistics for outcomes, demographics, diabetes severity and comorbidities for beneficiary groups receiving four, three, two, one and none of the diabetes process measures. We compared differences in group means using one-way ANOVA or Kruskal-Wallis Rank Test for interval variables and Chi-square for categorical variables. We employed multivariate logistic regression to model the association between the number of diabetes process measures in the prior year and diabetes ACSC & all ACSC hospitalization in the subsequent year. For beneficiaries who received one, two or three of the four process measures in the prior year, we modeled the association between the type of process measure set and diabetes ACSC & all ACSC hospitalization in the subsequent year using stratified multivariate logistic regresssion models. This allowed us to compare whether some diabetes process measures were more important than others in predicting of hospitalizations in the subsequent year. We ran separate analysis for the two hospitalization outcomes.

In the models, we controlled for beneficiary's (i) **demographic characteristics:** age (<60 years, 60-64 years, 65-69 years, and 70-75 years) , sex, race (White, Black, Hispanic, Asian and Other) , Medicare-Medicaid dual eligible status, rural-urban status, median zip code income and median zip code education (ii) **diabetes severity in 2006**: Type I diabetes, insulin pump use (from part B and DME claims), self-monitoring of blood glucose (from durable medical equipment claims) and years of diabetes duration from CCW records (iii) **comorbidity in 2006**: using 70 hierarchical condition categories (HCCs) computed using the CMS HCC model on beneficiary's claims for 2006 and (iv) **outcomes in 2006**: we also controlled for whether the beneficiary was hospitalized for micro/macro vascular hospitalizations or ASC hospitalizations in 2006.

We performed sensitivity analysis where we controlled for observed confounding, using propensity score inverse probability treatment weighting-for the propensity to receive the diabetes process measures (modeled as 0-4)[5]. Results of the propensity score inverse probability weighting did not differ from that obtained with simple logistic regression results and are not reported here.

All standard errors were robust in multivariate analyses. ***P*** values were 2-sided with a level of significance of ≤.05. We used SAS version 9.1 [49] and STATA 12 [50] for all analyses.

RESULTS

Table 3.1 shows the descriptive statistics for our beneficiary cohort, stratified into subsamples based on the number of ambulatory diabetes care process measures they received in 2006. Seven percent of the beneficiaries received none of the diabetes care process measures. Only 22 percent of the beneficiaries received all four process measures. The all-or-none approach would deem the remaining 88 percent of the beneficiaries as not having received ambulatory diabetes care of creditable quality, even though 37 percent and 24 percent received three and two process measures respectively. Beneficiaries who

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[5] *Weighting with inverse probability treatment weights of propensity scores is an efficient approach that uses all available data and does not require any arbitrary decisions with regards to stratification into groups or matching. We applied inverse probably treatments weights of the propensity score in the following steps. We first employed multinomial logistic regression to obtain the probability of receiving 0-4 process measures for each beneficiary. We then estimated the probability of having a hospitalization outcome in the subsequent year based on receipt of number of process measures by the beneficiary, beneficiary covariates and the beneficiary's inverse probability propensity score treatment weight. We carried out separate analyses for the two hospitalization outcomes.*

received two or three process measures were more likely to have HbA1c testing and Lipid Testing, and least likely to have dilated eye examinations. 10 percent of the beneficiaries who received only one process measure were more likely to receive HbA1c (29%) and least likely to receive nephropathy testing (20%).

Beneficiaries receiving fewer than four diabetes process measures were more likely to be- disabled (<65 years), male, non-white, dual eligible, and reside in rural areas, or in zip codes with lower median income and education. Beneficiaries receiving all the process measures were more likely to have Type 1 diabetes, used insulin pump, suffered from the disease for a longer-duration, and less likely to have multiple comorbidities- as evinced from their average HCC scores. These beneficiaries were also more likely monitor their own blood glucose level (measured from their durable medical equipment claims for the year), receive influenza vaccination, cancer screening, attend diabetes education programs, see an endocrinologist, and have more evaluation and management visits for their disease during the measure year, than beneficiaries who received fewer than four process measures. Finally, the rates of diabetes ACSCs and all ACSCs, in both the measure year and subsequent year, were lower for beneficiaries who received all four of the diabetes process measures.

Table 3.2 shows results from the multivariate logit models predicting the likelihood of hospitalizations for diabetes ACSCs and all ACSCs in the subsequent year, based on the number of diabetes process measures in the prior year. Beneficiaries receiving all four measures had significantly lower risk[6] [51]of hospitalizations for the two outcomes than

[6] Given the low incidence of both the outcomes of interest in the subsequent year (<<10 percent), we can assume that the odds ratio approximate relative risk (Zhang & Yu 1998).

those receiving none, one or two measures. Beneficiaries receiving none of the diabetes process measures had a 119 percent higher risk of diabetes ACSC and 62 percent higher risk of all ACSC hospitalizations compared to those who received all four process measures. The relative risk of hospitalization for beneficiaries receiving one or two process measures, compared to those who received all, was lower, ranging from 20-40 percent. But th*ere was no significant difference in the likelihood of having hospitalizations for either diabetes ACSCs or all ACSCS in the subsequent year between beneficiaries receiving three diabetes process measures and those receiving four diabetes measures.* Beneficiaries receiving one, two, and three out of the four process measures had significantly lower risk of hospitalization for diabetes ACSC, (25 percent, 39 percent, and 45 percent, respectively), compared to beneficiaries receiving none of the process measures. The risk of all ACSC hospitalizations was also significantly lower for beneficiaries who received one (8%), two (24%) or three (31%) of the four process measures compared to those who received none.

Table 3.3 shows results from the multivariate logit models predicting the probability of hospitalization for diabetes ACSCs and all ACSCs in the subsequent year, based on the type of process measure beneficiaries received- for the sample of beneficiaries stratified into subgroups that received one, two or three process measures. Among beneficiaries who received two process measure, receiving *neither* LDLC *nor* HbA1c testing was associated with significantly higher relative risk of hospitalizations for diabetes ACSCs (44% higher than LDLC *and HbA1c testing*) and all ACSCS (35% higher than LDLC *and* HbA1c testing). There was no difference in the likelihood of hospitalization for diabetes ACSCs or ACSCs by type of measure set among beneficiaries who received one or three measures.

DISCUSSION

We examined the limitations and predictive validity of the all-or-none approach in measuring the quality of ambulatory diabetes care for the Medicare beneficiaries. Only 22 percent of beneficiaries in our study received all four of the recommended process measures during the year, echoing findings from prior studies that have shown low rates of recommended diabetes care measures for Medicare beneficiaries [52]. This is the biggest limitation of using the all-or-none approach for quality measurement for Medicare beneficiaries- where majority of the beneficiaries would be classified as failures rather than partial successes in reaching the quality bar. This problem would only be compounded with the addition of more criterion measures capturing different elements of care for the disease. Hence, there must be parsimony in selecting criterion measures for a disease while using the all-or-none approach.

The all-or-none approach to quality measurement does not distinguish between the 37 percent of beneficiaries in our study who received three of the four measures- and the 10 percent who received none, even though these two groups had very different subsequent ambulatory care related outcomes. We compared outcomes in the subsequent year-hospitalizations for diabetes ACSCs and all ACSCs, by the number of process measures beneficiaries received in the prior year, and found no difference in likelihood of hospitalizations for either outcome between beneficiaries receiving all four process measures and those receiving three of the four process measures- even though the all-or -none approach regards the former group to have met quality benchmark and the latter to have failed to meet the quality benchmark for the ambulatory diabetes care. The

discrimination works at the bottom as well; any is better than none. Beneficiaries who received one, two or three of the four process measures had much lower probability of hospitalizations for either outcome, compared to those who received none of the four process measures. The all-or-none approach to quality measurement lumps those who receive a subset of criterion quality measures together, and does not distinguish the incremental levels of quality among these beneficiaries.

The all-or-none approach assumes that anything less than good care is not acceptable. Like other approaches that do not involve measure weighting, it also assumes that that all components of care are "good care" and equally important for patient outcomes and experience. But all components of care are seldom equal when it comes to outcomes. Our comparison of the likelihood of diabetes ACSC and all ACSC hospitalizations among beneficiaries who received two measures showed that those who did not receive either LDL cholesterol or HbA1c testing in the prior year had poorer outcomes in the subsequent year. The choice of avoidable hospitalizations as the outcome of interest in our study, preferential biased it towards LDL cholesterol testing and HbA1c testing, rather than eye examinations. This is a limitation of Medicare claims data- in that the only observed outcomes attributable to ambulatory diabetes care are avoidable hospitalizations.

A few other limitations of this study must be acknowledged. The quality measures we studied- were claims computable process measures and not intermediate outcome measures like HbA1c control. The outcomes of interest we used in our study were limited by what could be readily measured from Medicare claims. Finally, our study controlled only for observed confounding using propensity scores. We did not control for bias due to

unobserved confounders like prescription drug use by beneficiaries- which is more often than not balanced in such large Medicare beneficiary samples. The low prevalence of hospitalization outcomes allowed us to infer odds ratios as relative risks. These limitations however do not impact the overall conclusions of our study.

CONCLUSION

In summary, even as the all-or-none approach to quality measurement is increasingly adopted because of its simplicity, ease of calculation and interpretation; it may neither be ideally suited for the Medicare population nor for measurement of quality of care for chronic conditions- where there are multiple care components with varying importance. This approach has poor predictive validity, discards meaningful & important quality information and has poor discrimination. The science of quality measurement would be better served with greater investment in the measurement and reporting of patient outcomes, to be used as the yardstick for developing weighted composites, which are truer measures quality of care.

Table 3.1: Comparison of Descriptive Statistics by Subsample based on Number of Diabetes Quality Process Measures in Prior Year

	ALL	**NONE**			
	4 MEASURES	3 MEASURES	2 MEASURES	1 MEASURE	0 MEASURES
Number of Beneficiaries	***42,015***	***72,020***	***46,969***	***20,279***	***13,062***
% of Total Sample	***21.6%***	***37.1%****	***24.2%****	***10.4%****	***6.7%****
Variable	**Mean (SD) or Percent**				
Outcome in Subsequent Year					
Hospitalizations for Diabetes ACSCs	1.4%*	1.6%*	2.0%*	2.5%*	2.2%*
Hospitalizations for All ACSCs	6.9%*	8.0%*	10.2%*	12.6%*	11.2%*
Demographic Characteristics					
Age: < 60 years	11.8%*	16.8%*	20.2%*	24.1%*	30.1%*
Age: 60-64 Years	37.3%*	33.3%*	31.3%*	29.7%*	25.0%*
Age: 65-69 years	7.2%*	8.7%*	9.3%*	10.3%*	10.7%*
Age: 70-75 Years	43.6%*	41.1%*	39.2%*	35.8%*	34.2%*
Sex: Female	59.6%*	55.9%*	53.6%*	50.1%*	41.1%*
Race: White	81.6%*	79.8%*	79.4%*	75.0%*	70.6%*
Race: Black	12.3%*	14.2%*	15.1%*	18.4%*	20.3%*
Race: Other	6.1%*	6.0%*	5.5%*	6.5%*	9.1%*
Rural	17.9%*	18.6%*	19.4%*	19.1%*	18.7%*
Dual Eligible	23.1%*	26.8%*	29.7%*	32.3%*	29.1%*
Disabled	16.8%*	23.0%*	26.9%*	31.7%*	38.7%*
Median Zip Code Income (In $10,000)	4.30*(1.59)	4.15* (1.51)	4.04* (1.45)	3.96* (1.41)	3.95* (1.43)
Median Zip Code	13.34*(1.12)	13.24* (1.10)	13.16* (1.08)	13.13	13.09 *(1.09)

	ALL	NONE			
	4 MEASURES	3 MEASURES	2 MEASURES	1 MEASURE	0 MEASURES
Number of Beneficiaries	***42,015***	***72,020***	***46,969***	***20,279***	***13,062***
% of Total Sample	***21.6%***	***37.1%****	***24.2%****	***10.4%****	***6.7%****
Education (In Years)				*(1.07)	
Diabetes					
Diabetes Type 1	22.0%*	19.7%*	17.7%*	14.8%*	10.1%*
Insulin Pump	5.4%*	5.0%*	4.6%*	4.7%*	4.1%*
Self-Monitoring of Blood Glucose	56.2%*	50.2%*	43.0%*	32.4%*	24.4%*
Diabetes Duration in Years	4.22*(2.4)	4.01* (2.4)	3.77 *(2.4)	3.56*(2.4)	3.45*(2.4)
HCC Score	1.29* (0.90)	1.38* (1.05)	1.49* (1.22)	1.56* (1.34)	1.27* (1.26)
Diabetes Measures and Utilization	4 MEASURES	3 MEASURES	2 MEASURES	1 MEASURE	0 MEASURES
HbA1c Measurement	***100.0%****	***95.2%****	***79.0%****	***29.0%****	***0.0%****
LDL Cholesterol Measurement	***100.0%****	***94.7%****	***76.7%****	***25.3%****	***0.0%****
Eye Exams	***100.0%****	***44.3%****	***19.5%****	***24.6%****	***0.0%****
Attention for Nephropathy	***100.0%***	***65.8%****	***24.8%****	***21.0%****	***0.0%****
Diabetes Education	7.0%*	5.2%*	3.6%*	1.9%*	1.2%*
Evaluation and Management Visit for Diabetes	81.6%*	71.6%*	59.7%*	45.5%*	31.7%*
Number of E&M Visits for Diabetes	2.8 (2.6)*	2.3 (2.6)*	1.7 (2.3)*	1.1 (1.9)*	*0.7 (1.5)

**Differences between groups significant at p<0.05*

Table 3.2: Results from Multivariate Logistic Regressions* Predicting the Likelihood of Hospitalization for Diabetes and All Ambulatory Care Sensitive Conditions (ACSC) in 2007 based on Number of Ambulatory Diabetes Care Processes in 2006

Number of Ambulatory Diabetes Care Processes in 2006	Diabetes ACSC Hospitalizations in 2007		ACSC Hospitalizations in 2007	
	Odds Ratio	***95% CI of Odds Ratio***	***Odds Ratio***	***95% CI of Odds Ratio***
Zero vs. All	2.19**	1.78-2.69	1.62**	1.51-1.75
One vs. All	1.64**	1.37-1.97	1.50**	1.41-1.60
Two vs. All	1.35**	1.16-1.58	1.24**	1.17-1.32
Three vs. All	1.16	1.00-1.35	1.05	0.99-1.11
One vs. Zero	0.75**	0.61-0.92	0.92**	0.86-0.99
Two vs. Zero	0.61**	0.51-0.74	0.76**	0.71-0.82
Three vs. Zero	0.55**	0.46-0.66	0.69**	0.64-0.74
Four vs. Zero	0.46**	0.37-0.56	0.61**	0.57-0.66

** Adjusted for beneficiary characteristics viz. age, sex, race, dual eligible status, rural-urban status, median zip code income, median zip code education, Type I diabetes, diabetes duration in years (as per CCW records), comorbidities using 70 hierarchical condition categories (HCCs) computed using the CMS HCC model on beneficiary's claims for 2006, self-monitoring of blood glucose, and hospitalizations for diabetes ACSC or All ACSC hospitalizations in 2006.*

*** Significant at p<0.05*

Table 3.3: Results from Multivariate Logistic Regressions * Predicting the Likelihood of Hospitalization for Diabetes and All Ambulatory Care Sensitive Conditions (ACSC) in 2007 based on Ambulatory Diabetes Care Processes within a Measure Set Subgroup in 2006

Measure Set Subgroup of Ambulatory Diabetes Care Processes in 2006	Diabetes ACSC Hospitalizations in 2007		All ACSC Hospitalizations in 2007	
	Odds Ratio	95% CI of Odds Ratio	Odds Ratio	95% CI of Odds Ratio
One Measure (Reference: LDLC)				
HbA1c	0.96	0.60-1.51	0.88	0.75-1.03
Eye Examination	1.19	0.78-1.83	1.03	0.89-1.20
Nephropathy Testing	1.34	0.86-2.07	1.09	0.94-1.27
Two Measures (Reference: LDLC+HbA1c)				
LDLC+Eye Examination	0.64	0.37-1.12	0.98	0.85-1.14
LDLC + Nephropathy Testing	0.69	0.41-1.16	1.04	0.92-1.19
HbA1c+ Eye Examination	0.99	0.73-1.34	1.04	0.92-1.18
HbA1c+ Nephropathy Testing	1.24	0.93-1.66	1.14	1.00-1.28
Eye Examination + Nephropathy Testing	1.44**	1.03-2.08	1.35**	1.15-1.58
Three Measures (Reference: LDLC+HbA1c+ Eye Examination)				
LDLC+HBA1C+ Nephropathy Testing	0.72	0.39-1.35	0.94	0.79-1.11
LDLC+ Eye Examination + Nephropathy Testing	1.08	0.88-1.31	1.02	0.95-1.09
HbA1c+ Eye Examination + Nephropathy Testing	1.24	0.89-1.71	1.08	0.95-1.23

** Adjusted for beneficiary characteristics viz. age, sex, race, dual eligible status, disability, rural-urban status, median zip code income, median zip code education, Type I diabetes, diabetes duration in years (as per CCW records), comorbidities using 70 hierarchical condition categories (HCCs) computed using the CMS HCC model on beneficiary's claims for 2006, self-monitoring of blood glucose, and hospitalizations for micro/macro vascular complications or ASC hospitalizations in 2006. ** Significant at p<0.05*

CHAPTER 4: COMPOSITE QUALITY OF AMBULATORY DIABETES CARE: COMPARING APPROACHES TO WEIGHTING MEASURES

Objective: Current approaches to composite quality measurement for diabetes care weight all measures equally, even when they are not equally important for either diabetes care or outcomes. The correct approach to weighting measures in a composite depends on whether the measures are viewed as effects of unobserved quality, or causes of quality- which might be unobserved or observed as outcomes. Accordingly we compare measure weights for four diabetes care processes using three alternate approaches for developing weighted composites: 1) factor-based weighting 2) physician-based weighting and 3) outcomes-based weighting, to study whether equal weighting of these process measures is justified in practice.

Methods: A retrospective cohort design following a 5 percent nationally representative sample of 194,345 fee-for-service Medicare beneficiaries with diabetes, aged 18-75 years in 2006, who were alive at the end of 2007. We used confirmatory factor analysis on two split-half samples to examine factor loadings of four diabetes care process measures and eight ambulatory care process measures on an underlying quality factor. We asked a technical expert panel of eight physician quality leaders to rate the four process measures based on the relative importance to quality. We employed multiple logistic regressions with propensity score inverse probability treatment weighing to compare the association of the four process measures on hospitalizations for ambulatory care sensitive conditions associated with diabetes and all ambulatory care sensitive conditions in the following year.

Results: *HbA1c testing and LDLC testing loaded more strongly on the single underlying factor than eye exams and testing for nephropathy. The eight ambulatory care measures, related and unrelated to diabetes also loaded on the same single underlying factor. Physicians in the technical expert panel rated all four measures as equally important to quality. HbA1c testing and LCLC testing were associated with significantly lower risk of hospitalizations for diabetes ACSCs, while eye exams and testing for nephropathy were not.*

Conclusion: Current approaches to composite quality measurement weight all measures in the diabetes measure set equal. While physician quality leaders endorse this dogma, measures like HbA1c and LDLC measurement are more strongly related to quality of diabetes care than eye exams or testing for nephropathy.

BACKGROUND

Diabetes care has been a prominent focus of ambulatory care quality measurement and improvement initiatives over the last two decades, since the first national effort to develop a set of performance measures for the disease was convened in 1995 [36]. Apart from being incorporated as measures of plan quality in Healthcare Effectiveness Data and Information Set (HEDIS), payers and providers have more recently adopted diabetes quality measures for use at the physician or group practice level with payment programs such as Medicare's Physician Quality Reporting System (PQRS) and Accountable Care Organization (ACO) demonstrations [3-5, 53]]. The move towards pay-for-performance and value-based purchasing has highlighted the need for summary measures for diseases/conditions spurring development of composite quality measurement.

The National Quality Form defines a composite measure as a combination of two or more measures into a single measure, resulting in a single score[53]. Composites have the

potential of enhancing measurement, beyond the mere tracking of performance on separate measures, by determining whether critical aspects of care for a given condition have been achieved for an individual patient [54]. By providing an overall summary of quality of care, composites can allow for comparison of providers over multiple domains of care. Composites also have higher reliability than unaggregated measures, allowing for comparison of providers with smaller patient samples [23]. However, composites are harder to interpret and more difficult to validate than individual measures. There is also a lot of debate how to combine measures to create a composite[7] [23]. In practice, different scoring methods used to create quality composites have yielded different provider rankings, making the comparison of quality between providers onerous [25]

The rationale for weighting measures in a composite and how to weight them is also is also a subject of debate [23]. Unaggregated measures in the diabetes measure set are not equally important for diabetes care or outcomes - making the case for weighting them accordingly in the composite. The approach used to weight unaggregated measures should be based on the importance of these measures for either diabetes care or subsequent outcomes. Quality can be theoretically viewed as either the cause or effect of these

[7] Unaggregated measures can be combined to yield a composite, using linear scoring, multiplicative scoring, or opportunity scores. In linear scoring, the composite is a linear combination of the individual items that could be equally or diffentially weighted. In multiplicative or all-or-none scoring the composite is a product of the individual items that are always equally weighted. There are two types of opportunity scores- indicator averages and patient averages. Indicator averages are created by dividing the number of eligible patients who receive recommended care for each measure by the number of eligible patients. Patient averages are the care opportunities that were met for each patient, providing a measure of average quality of care provided to a sample of patients. (Reeves et al 2007)

unaggregated measures[8] [23]. In the former case, factor analysis can be employed to weight how important the unaggregated measures are to the unobserved quality of ambulatory diabetes care construct. In the latter case, unaggregated measures can be weighted using expert judgment - based on how important they are to the unobserved quality of care of ambulatory diabetes care construct [26], or empirically- based on how these measures predict subsequent observed outcomes associated with ambulatory diabetes care, such as. avoidable hospitalizations[27, 41].

In this paper we compare three approaches to weighting measures for measuring composite quality of ambulatory diabetes care: (i) factor-based weighting (ii) physician-based weighting and (iii) outcomes-based weighting. The unaggregated measures chosen for the composite are four claims-computable diabetes process measures for fee-for-services Medicare beneficiaries, viz. annual hemoglobin A1c (HbA1c) testing, annual low density lipoprotein cholesterol (LDLC) testing, annual dilated eye exams and annual testing for nephropathy. These process measures have long been part of the diabetes HEDIS measure set for Medicare Advantage plans- where they are weighted equally in the diabetes quality composite [24]. These measures are also part of the diabetes measure set to be used for Medicare's physician value-based modifier payments [6]. We compare the weights assigned to these four process measures from three different approaches to weighting to ask whether equally weighting of these measures is warranted or not. .

[8] Since quality is an abstract concept- it is viewed as a latent variable. Observed unaggregated measures could either be viewed as effects of an underlying quality construct (reflective measurement model) or causes of the quality construct (formative measurement model). The approach employed to weight measures depends on whether the relationship of the observed measures with the quality construct is viewed as reflective or formative.

METHODS

DATA AND STUDY SAMPLE

This study employed data from the 2006 and 2007 Chronic Condition Data Warehouse (CCW) 5 percent Medicare sample. Specifically, we used personal summary, inpatient, outpatient, carrier claims files for a 5 percent random sample of Medicare beneficiaries. We also used Small Area income and education data sets from the Census Bureau and Area Resource File.

Our study sample consisted of Medicare fee-for service beneficiaries with diabetes, who were alive at the end of 2007. Beneficiaries were continuously enrolled in Part A (coverage for hospital care) and Part B (coverage for physician care), with no months of managed care enrollment for both years. We identified beneficiaries with diabetes using the chronic condition flag for the disease [55]. We applied additional restrictions so that our sample met the HEDIS denominator definitions for quality: we excluded beneficiaries older than 75 years in 2006, those with HIV, active cancer treatment, organ transplant and end-stage-renal disease (see Appendix 1 for exclusions) [44]. The final cohort consisted of 194,345 beneficiaries.

PROCESS MEASURES FOR QUALITY OF AMBULATORY DIABETES CARE

From the beneficiaries' claims for 2006 we identified whether beneficiaries had received the following diabetes process measures during the year:(i) HbA1c test (ii) LDLC test (iii) dilated eye exam[9] (iv) testing for nephropathy[10]. The definitions of these measures and the codes used to identify them from claims are summarized in Appendix 2.

[9] The HEDIS measure set counts any E&M visit to an Ophthalmologist or Optometrist as an eye exam. We use a more conservative definition of the process measure to include only dilated retinal exams.

FACTOR WEIGHTED COMPOSITE

While employing factor analysis, we assume that observed process measures for diabetes are effects of an underlying factor- the quality of ambulatory diabetes care. Any observed correlation between the processes measures at the beneficiary level can be explained by this factor. Our objective was to find the single underlying latent factor (quality) and identify how strongly process measures loaded on the factor[11] .

The sample of beneficiaries in 2006 was randomly split into two half-samples. We performed confirmatory factor analyses (CFA) with both half-samples with the four diabetes process measures in the measurement model. We compared the loadings of process measures on the factors from the two analyses, examined the goodness of fit

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[10] The HEDIS measure set defines attention for nephropathy as documentation of nephropathy or testing for nephropathy. We define the process measure to include only testing for nephropathy.

[11] The underlying variable approach assumes that the dichotomous process measures x_i are in fact continuous variables x^*_i, which actually measure the underlying latent factor f, but we can only 'partially observe' x^*_i though x_i

The dichotomous variable x_i, $x_i = 0$ if $-\infty < x^*_i \leq \tau_i$; and $x_i = 1$ if $\tau_i < x^*_i$

Where, τ_i is the threshold value.

According to the linear factor model, x^*_i is:

$x^*_i = \mu + \Lambda f + \varepsilon$

where, f is the common factors, assumed to be random such that $E(f) = 0$ and $Var(f) = I$; ε is a random error, such that $E(\varepsilon) = 0$ and $Var(\varepsilon) = \Psi$; Λ is the matrix of factor loadings that describe how the variables are related to the factor; and μ a set of scalars commonly set to 0 for computational ease.

statistics and weighted each process measure by its factor loading scaling the total to 4[12]. We used the average weight from the two factor analyses to get the final factor weight for each process measure. To examine whether the underlying factor was associated with ambulatory diabetes care or any ambulatory care we repeated these steps for an expanded measure set of eight ambulatory care process measures, related and unrelated to diabetes: (i-iv) the four diabetes process measures, (v) annual ambulatory care visit for diabetes, (vi) participation in a diabetes program (diabetes self-management education or medical nutrition therapy), (vii) influenza vaccination, and (viii) screening for breast or prostate cancer. The definitions of these measures and the codes used to identify them from claims are also summarized in Appendix 2.

PHYSICIAN WEIGHTED COMPOSITE

The physician weighted composite is based on the opinion of an expert physician panel regarding the relative importance of diabetes process measures in determining unobserved quality of ambulatory diabetes care. The assumption implicit here is that physicians can judge how strongly diabetes process measures 'cause' the ambulatory diabetes care quality construct. We obtained relative weights for the diabetes processes from a physician expert panel[13] that was convened to evaluate and rate quality measures

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[12] The weight assigned to process measure m is, $W_m=[L_m / \sum_{m=1}^{4} L_m]x\ 4$; where L_m is the factor loading of the measure on the underlying factor.

[13] This expert panel was convened as part of a CMS project Alternative Measures of Physician Resource Use (HHSM-500-2005-000271 Task Order 0004).

that were useful for measuring quality of care provided in an ambulatory care setting. The panel had eight physicians in leadership roles in physician practices. These physicians were actively involved in state or national professional association activities in quality assessment and performance measurement. First, members of the panel were introduced to the quality measures to be rated and explained the rating process that was to follow, over an in-person meeting. The raters were then interviewed to confirm that they clearly understood the rating exercise- and the rating process was then carried out.

The physicians in the expert panel were asked to rate the usefulness of the four diabetes process measures in measuring ambulatory care quality, along with the usefulness of 180 other quality measures used in CMS's Physician Quality Reporting System [3]. Physicians were asked to rate the measures using a scale of 0-100, where 100 represented the highest utility for measuring quality of ambulatory care and zero meant that a particular measure should not receive any consideration. We obtained the average physician rating for each diabetes process measure, and weighted each measure as follows:

$$W_m = [\, Avg_m \,/\, \sum_{m=1}^{4} Avg\ m] \times 4$$

Where Avg_m was the average rating given to the measure (out of 100) by the physician panel. To measure inter-rater reliability, we calculated intra-class coefficient using two-way analysis of variance with random effects for raters [56].

Outcomes Weighted Composite

The outcomes weighted composite for ambulatory diabetes care is based on the assumption that diabetes process measures 'cause' subsequent ambulatory diabetes care outcomes- and that this association can be measured empirically. The weights for process

measures are determined by how they empirically predict avoidable hospitalization outcomes in the subsequent year.

Choice of Outcomes and Regression Analysis

We chose two outcomes in the subsequent beneficiary year that were closely tied to quality of ambulatory care for diabetes:

(i) Hospitalizations for ambulatory care sensitive conditions associated with diabetes (diabetes ACSCs): These were hospitalizations for complications of diabetes, uncontrolled diabetes, hypoglycemia, and hypertension [41].

(b) Hospitalization for all ambulatory care sensitive conditions (ACSCs): These are a larger set of hospitalizations , defined by the Agency for Healthcare Research and Quality, that can be avoided by better ambulatory care (all ACSCs) [41].

We identified hospitalizations for diabetes ACSCs and all ACSCs in 2007 (see Appendix 3 for a list of conditions and diagnosis codes for hospitalizations). We modeled the association between diabetes process measure in the prior year and hospitalization in the subsequent year, using models discussed below. We ran separate analyses for each of the four process measures (as they are moderately correlated with one another at the beneficiary level) and the two hospitalization types. In the models, we controlled for beneficiary's (i) **demographic characteristics:**. age (<60 years, 60-64 years, 66-69 years, and 70-75 years) , sex, race (White, Black, Hispanic, Asian and Other) , dual eligible status, rural-urban status, median zip code income and median zip code education (ii) **diabetes severity in 2006**: Type I diabetes, insulin pump use (from part B and DME claims), self-monitoring of blood glucose (from durable medical equipment claims) and years of diabetes duration from CCW records (iii) comorbidity **in 2006**: using 70 hierarchical

condition categories (HCCs) computed using the CMS HCC model on beneficiary's claims for 2006 [57] (iv) **outcomes in 2006**: we also controlled for whether the beneficiary was hospitalized for micro/macro vascular hospitalizations or ACSC hospitalizations in 2006.

Controlling for observed confounding using Propensity Score Inverse Probability Treatment Weighting:

Estimating the effect of process measures on predicting outcomes in the subsequent year, required us to control for observed confounding, using propensity score inverse probably treatment weighting [58]. We first employed multivariate logistic regression to obtain the probability of each beneficiary receiving the process measure. For beneficiaries who received the process measure, the inverse probability treatment weighting assigns a weight of 1/p , and for those who did not receive the process weight assigned is 1/ (1-p). We then estimated the probability of having a hospitalization outcome in the subsequent year based on receipt of the process measure by the beneficiary, beneficiary covariates and the beneficiary's inverse probability propensity score treatment weight, using multivariate logistic regression. We carried out separate analyses for each process measure and outcome.

We attempted to control for both observed and unobserved confounding using instrumental variables. However we did not find suitable instruments that were associated with the process measures and not otherwise associated with the hospitalization outcomes. An instrument that we considered to be predictive of beneficiaries getting diabetes process measures was percentage of Medicare beneficiaries in the county enrolled in Medicare Advantage plans. However this instrument has been shown to be related to ASCSs at the area level [59].

All standard errors were robust in multivariate analyses. ***P*** values were 2-sided with a level of significance of ≤.05. All analyses were performed using SAS 9.2 [49] and STATA 12[50].

We weighted each process measure based on the percentage decrease in the relative risk[14] [51] of outcome in the subsequent year it was associated with, scaling the composite to 4[15]. Finally we compared the rank order of weights of diabetes process measures across all three quality composites.

RESULTS

The characteristics of our study sample are summarized in Table 1. Our of sample of diabetics was predominantly type II diabetics (81 percent), white (79 percent), female (54 percent), and non-rural (82 percent).Congestive heart failure, arthritis and coronary artery disease were the common comorbidities in over 20 percent of the population. The rate of annual HbA1c testing, LDLC testing, dilated eye exams and nephropathy testing in our beneficiary sample were 79 percent, 78 percent, 45 percent and 44 percent respectively. The rates of self-monitoring of blood glucose, influenza vaccination and cancer screening in the population were high as the rates for eye exams and nephropathy testing. While 96

[14] Given the low incidence of both the outcomes of interest in the subsequent year (<10 percent), we assume that the odds ratio approximate relative risk (Zhang & Yu 1998).

[15] The weight assigned to process measure m is , $W_m=[(1-RR_m)/\ \sum_{m=1}^{4}(1-RRm)]$x 4, where RR_m is the relative risk for the measure in lowering the probability of avoidable hospitalizations in the subsequent year.

percent of the beneficiaries had an annual ambulatory care visit, only 65 percent of them had an ambulatory care visit for diabetes. Finally the rate of hospitalizations for diabetes ACSCs and all ACSCs were approximately 1.8 percent and 9 percent, respectively, for both years.

Factor Based Weighting of Process Measures

All four ambulatory diabetes care process measures loaded strongly on a single underlying factor. The result of the factor score weighting, presented in Table 2, summarizes the results from CFA using both half-samples. The underlying quality of ambulatory diabetes care construct captured 60 percent of the variation in the diabetes process measures. The single factor model fit the data very well, as evinced by the high comparative fit index (0.9>) and very low standardized root mean square residual (~0). HbA1c testing and LDLC testing loaded more strongly on the underlying quality factor (with weights of 1.4 out of 4), while dilated eye exams had the lowest loading on the factor (with a weight of 0.5 out of 4). The expanded set of eight ambulatory care process measures (related to & unrelated to diabetes) also loaded on strongly a single underlying factor. The underlying ambulatory care quality construct captured 65 percent of variation in the eight process measures. Fit statistics showed that the single factor solution fit the data very well. HbA1c and LDLC testing loaded more strongly on the underlying factor than E&M visit for diabetes. However preventive measures like influenza vaccination and cancer screening loaded more strongly on the factor than eye exams or testing for nephropathy.

Physician Based Weighting of Process Measures

Physician weighting for the diabetes process measures is shown in Table 3. Scores for the four process measures were quite similar, ranging from 84 to 89 (on a scale of 0 to 100).

There was marginally higher variation in the scores for eye exams and nephropathy testing, compared to HbA1c and LDLC testing. The intra class coefficient with rater random effects was 0.49, indicating moderate inter-rater reliability between physician raters, when the raters were assumed to be selected from a larger sample of physicians. The intra class coefficient with rater fixed effects was 0.67, indicating that the physicians in the panel were not likely to score measures in a similar manner. Physician raters in the Technical Expert Panel weighted all the process measures as equally important for the quality of ambulatory diabetes care, when the measures were reweighted to a scale of 4.

OUTCOMES-BASED WEIGHTING OF PROCESS MEASURES

Results from the outcomes based weighting of the process measures using propensity score inverse probability treatment weighting are summarized in Table 4. Among the process measures, LDLC testing in the prior year was significantly associated with lowering the relative risk[16] [51]of diabetes ACSCs by 27 percent, followed by HBA1c testing (25 percent). Eye exams and testing for nephropathy were not associated with lowering the likelihood of diabetes ACSCs in the subsequent year. All four process measures were independently associated with a 52 percent reduction in relative risk of diabetes ACSCs. We assigned outcomes based weights, on the basis of how much each process measure contributed to lowering the risk of hospitalization. Accordingly, LDLC testing was given a weight of 2.1 [(27 percent/52 percent)x4], HBA1c testing received weight of 1.9 [(25 percent/52 percent)x4]. Eye exams and testing for nephropathy were assigned weights of zero as they were not associated with significantly lowering the risk of

[16] Given the low incidence of both the outcomes of interest in the subsequent year (<10 percent), we assume that the odds ratio approximate relative risk (Zhang & Yu, 1998)

diabetes ACSCs. The association of LDLC testing in lowering the risk of all ACSCs was lower than that for diabetes ACSCs- at 23 percent, followed by HBA1C testing (13 percent), eye exams (9 percent) and testing for nephropathy (4 percent). Accordingly the four measures received weights of 1.9, 1.1, 0.7 and 0.3 respectively out of 4. Among the four measures, LDLC testing and HbA1c testing had the highest association, while eye exams and testing for nephropathy had the lowest association with risk reduction for either hospitalization in the subsequent year.

We compared the relative ranking of the four process measures weights from the alternative weighting approaches in Table 5. The physician panel weighted all diabetes process measures as equally important. Factor-based weighting gave the highest weights to HbA1c testing and LDLC testing, followed by nephropathy testing and eye exams. Empirical weighting of the diabetes care process measures based on their association with hospitalizations for diabetes ACSCs and all ACSCs in the subsequent year, assigned LDLC testing the highest weight, followed by HbA1c testing; while nephropathy testing and eye exams received the lowest weights.

DISCUSSION

Our paper challenges the current practice of weighting all diabetes process measures as equally important for composite quality of ambulatory diabetes care. Weighting approaches employed by CMS/HEDIS (linear scoring) or Minnesota Community Measurement (multiplicative scoring) weight all diabetes process measures equally- even when some measures are based on consensus rather than evidence. Our physician expert-panel - consisting of physician leaders in quality measurement- endorsed this dogma, weighting all diabetes process measures as equally important.

Results from factor-based weighting showed that while treating Medicare beneficiaries with diabetes, physicians performed HbA1c testing and LDLC testing more than testing for nephropathy or eye exams (which are not usually not performed by primary care practitioners treating diabetes) The former two diabetes process measures loaded more strongly than the latter two, on an underlying common factor assumed to be quality of ambulatory diabetes care. However using an a larger set of ambulatory care measures- that were either related or unrelated to diabetes care, we found that process measures unrelated to diabetes care also loaded on the same underlying factor. Hence the underlying factor that these diabetes process measures loaded on- was more likely to measure **propensity for ambulatory care processes**- rather than quality of ambulatory diabetes care.

Management of hyperglycemia and hyperlipidemia – measured by HbA1c and LDLC testing, respectively, were associated with lowering the risk of hospitalizations for diabetes ACSCs and ACSCs in the subsequent year. Eye exams and testing for nephropathy were not associated with reducing the risk of avoidable hospitalizations related to diabetes, but had a low association in lowering the risk of ACSC hospitalizations. This effect is probably due to the two measures being correlated with the underlying **propensity for ambulatory care processes construct.** These two process measures were also not deemed as important as HbA1c or LDLC testing by physicians treating Medicare beneficiaries. Eye exams and testing for nephropathy are consensus based measures in the HEDIS diabetes measure set. These two process measures are measures of care related to diabetes progression (retinopathy/nephropathy) rather than measures associated temporally with better hospitalization outcomes.

It could be argued that lower outcome-based weight for eye exams could be expected, given that eye exams are carried out by ophthalmologists who do not provide usual ambulatory care associated with diabetes. Moreover, beneficiaries are not expected to be hospitalized for diabetic retinopathy or its complications. The latter is a limitation of outcomes based weighting, in that the relative importance of the measure depends on the outcome chosen. However both factor-based weighting and outcomes-based weighting gave similar results for the relative weights of process measures. Measures that physicians providing ambulatory diabetes care gave more importance to were also more strongly associated with lowering the risk of diabetes ACSC and all ACSC hospitalizations in the subsequent year. The greater importance to management of hyperglycemia and hyperlipidemia in ambulatory diabetes care is keeping with evidence from large epidemiological studies like UK Prospective Diabetes Study and randomized control trials like Action to Control Cardiovascular Risk in Diabetes [ACCORD] [60].

Outcomes-based and factor- based approaches to creating composites are premised on alternative views of the ambulatory care quality construct. While both approaches incidentally yield identical results in our study, they have different implications for how physicians and policy makers approach the culture of ambulatory care quality. If ambulatory care process measures are viewed as effects of the underlying quality construct, then quality improvement efforts should be focused on the underlying quality culture in ambulatory care practice. Focusing quality improvement efforts at the level of processes measures, which in this case are merely manifests of the underlying ambulatory care quality construct, would not truly improve the quality of care[28]. If on the other hand, ambulatory care process measures are viewed to cause quality (unobserved as a latent construct or

observed as outcomes) , then quality improvement efforts should be focused on improving process measures at the patient level. Improving measures, in this case, would result in quality improvement [28].

We acknowledge various limitations of this study. Our study used diabetes process measures that could be directly obtained from Medicare claims to create the quality of care composite. Intermediate outcome measures like HbA1c control or LDLC control, and other intermediate process measures like use of drugs such as statins, glycemic agents, aspirin etc., were not available on the Medicare claims that we used. The effect of process measures on outcomes could be mediated through intermediate outcomes. The effect of process measures on outcomes could also be mediated through the underlying ambulatory care construct that the measured loaded on. Our study controlled mainly for observed confounding. We attempted to control for unobserved confounding (arising from omission of intermediate measures) using IVA in our sensitivity analyses- but the instrument at hand (number of Medicare advantage enrollees/1000 Medicare beneficiaries in the County) was suspect as it has been shown to be related to ACSC hospitalizations at the area level [59]. Finally, while the opinion of the physician expert panel was consistent with the views of quality measurement movements in the country, their judgment on the importance of diabetes process measures could very well be different from physicians who provide care to patients with diabetes. We however believe the strengths of this study outweigh these few limitations.

CONCLUSION

Irrespective of how the quality construct is viewed, this paper shows that current practices of treating all process measures as equally important for the quality of ambulatory

diabetes care is potentially specious. Even though physician leaders advocate equal importance of all process measures- practicing physicians treat certain measures as more important than others while providing care to Medicare beneficiaries with diabetes. Some process measures were also found to be more strongly associated than others with better patient outcomes in the subsequent year. While equal weighting of measures in a composite is simple and easy to implement- it is definitely not warranted unless all measures in the composite are truly equal. With the increased adoption of more evidence and consensus based quality measures, it is vital to ascertain the importance of measures by examining their association with patient outcomes even prior to their adoption. But the current state of quality measurement for Medicare beneficiaries is limited by the beneficiary level outcomes that are readily available. Further investment in outcomes research is needed to improve the practice of quality measurement- which risks being naïve in its current state.

Table 4.1: Study Sample Description

Number of Beneficiaries: 194,345

Variable		Mean (SD) or Percent
Diabetes Measures and Utilization		
	HbA1c Measurement	79.04%
	LDL Cholesterol Measurement	77.90%
	Retinal Eye Exams	45.30%
	Testing for Nephropathy	44.18%
Demographic Characteristics		
	Age < 60 years	18.2%
	Age 60-64 Years	8.0%
	Age 65-69 years	34.1%
	Age 70-75 Years	39.7%
	Female	54.50%
	White	79.0%
	Black	14.9%
	Other	6.1%
	Rural	18.26%
	Dual Eligible	27.44%
	Median Zip Code Income (In $10,000)	4.12(1.51)
	Median Zip Code Education (In Years)	13.22(1.10)

Number of Beneficiaries: 194,345

Variable		Mean (SD) or Percent
Diabetes		
	Diabetes Type 1	18.56%
	Insulin Pump	4.9%
	Self- Monitoring of Blood Glucose	46.15%
	Diabetes Duration in Years	3.9 (2.4)
Comorbidities		
	Atrial Fibrillation	6.34%
	Dementia	5.43%
	Coronary Artery Disease	20.92%
	Chronic Kidney Disease	15.08%
	Chronic Obstructive Pulmonary Disorder	12.63%
	Congestive Heart Failure	22.06%
	Glaucoma	10.80%
	Depression	15.08%
	Osteoporosis	8.38%
	Arthritis	22.11%
	Stroke	4.74%
Diabetes Utilization		
	Diabetes Program (MNT or DSME)	4.58%
	Influenza Vaccination	48.14%

Number of Beneficiaries: 194,345

Variable	Mean (SD) or Percent
Cancer Screening (Mammogram for Women/PSA for Men)	45.15%
Evaluation and Management Visit	96.56%
Number of E&M Visits	10.38(8.2)
Evaluation and Management Visit for Diabetes	65.49%
Number of E&M Visits for Diabetes	2.04 (2.49)
Outcome in Subsequent Year	
Diabetes ACSCs	1.8%
All ACSCs	9.2%
Hospitalizations in Prior Year	
Diabetes ACSCs	1.9%
All ACSCs	9.4%

Table 4.2: Results of Confirmatory Factor Analysis and Scaled Factor Score Weights for Ambulatory Diabetes Care Processes and All Ambulatory Care Processes

	CFA (Half-Sample-1) *N= 97,000*		**CFA (Half-Sample-2)** *N= 97,000*	
	Factor Loading (SE)	**WEIGHT** (Out of 4)	**Factor Loading (SE)**	**WEIGHT** (Out of 4)
Model 1: Ambulatory Diabetes Care Processes*				
HbA1C Testing	1.00(Restricted)	1.4	1.00(Restricted)	1.4
LDL Cholesterol Testing	1.03(0.01)	1.4	1.03(0.01)	1.4
Dilated Eye Exam	0.33 (0.01)	0.5	0.33 (0.01)	0.5
Testing for Nephropathy	0.54(0.01)	0.7	0.53(0.01)	0.7
Model 2: All Ambulatory Care Processes**				
HbA1C Testing	1.00(Constrained)	1.8	1.00(Constrained)	1.8
LDL Cholesterol Testing	0.88(0.01)	1.5	0.87(0.01)	1.5
Eye Exam	0.40 (0.01)	0.7	0.40 (0.01)	0.7
Testing for Nephropathy	0.50 (0.01)	0.9	0.51 (0.01)	0.9
Evaluation and Management Visit for Diabetes	0.71 (0.01)	1.3	0.72 (0.01)	1.3
Screening for Cancer	0.55 (0.01)	1.0	0.55 (0.01)	1.0
Influenza Vaccination	0.40 (0.01)	0.7	0.40 (0.01)	0.7
Diabetes Program (Nutrition Therapy or Self-Management Education)	0.09 (0.002)	0.1	0.10 (0.002)	0.1

** **Model goodness of fit:** Root mean squared error of approximation: 0.026; Comparative fit index: 0.95; Coefficient of determination: 0.60*

*** **Model goodness of fit:** Root mean squared error of approximation: 0.064; Comparative fit index: 0.85; Coefficient of determination: 0.65.*

Table 4.3: Results of Physician Technical Expert Panel and Physician Weights for Quality of Ambulatory Diabetes Care

	Average Score out of 100 (S.D)	**Inter Rater Reliability** **N=8** **Measures=4**	**Physician** **Weight (Out of 4)**
HbA1C Testing	89 (6.9)	Mean Square *Rater* : 323.98 Mean Square *Measure*: 181.20 Mean Square Error: 89.88 Shrout-Fleiss **Intra Class Correlation Coefficient** (With **Rater Random Effects**) : **0.49** Shrout-Fleiss **Intra Class Correlation Coefficient** (With **Rater Fixed Effects): 0.68**	**1.0**
LDL Cholesterol Testing	87 (7.8)		**1.0**
Dilated Eye Exam	84 (8.2)		**1.0**
Testing for Nephropathy	86 (7.8)		**1.0**

Table 4.4: Results of Outcomes Based Weighting using Multivariate Logistic Regression with Propensity Score Inverse Probability Treatment Weighting

	Hospitalization for Diabetes Ambulatory Care Sensitive Conditions in 2007		Hospitalization for All Ambulatory Care Sensitive Conditions in 2007	
Multivariate Logistic Regression with Propensity Score Inverse Probability Treatment Weighting				
Diabetes Process Measure in 2006	**Relative Risk (95% CI)**	**Outcomes Based Weight (Out of 4)**	**Relative Risk (95% CI)**	**Outcomes Based Weight (Out of 4)**
HbA1C Testing	0.75 (0.63-0.89) **	**1.9**	0.87 (0.84-0.90) **	**1.1**
LDLC Testing	0.72 (0.62-0.82) **	**2.1**	0.77 (0.75-0.79) **	**1.9**
Eye Exam	0.91 (0.76-1.1)	**0**	0.91 (0.88-0.93) **	**0.7**
Nephropathy Testing	0.93 (0.83-1.0)	**0**	0.96 (0.94-0.98) **	**0.3**

*** Significant at p<0. 05. Notes: Multivariate model adjusted for beneficiary characteristics viz. age, sex, race, dual eligible status, rural-urban status, median zip code income, median zip code education, Type I diabetes, diabetes duration in years), comorbidities using 70 hierarchical condition categories (HCCs) computed using the CMS HCC model on beneficiary's claims for 2006, self-monitoring of blood glucose, and hospitalizations for diabetes ACSC or All ACSC hospitalizations in 2006.*

Table 4.5: Relative Ranking of Measures by Importance using Different Approaches to Weighting

Diabetes Process Measure in 2006	Current Approaches[+] to Weighting	Physician Based Weighting	Factor Based Weighting	Outcomes Based Weighting Propensity Score IPTW*	
				Diabetes ACSC Hospitalization	All ACSC Hospitalization
HbA1C Testing	1	**1**	**1**	**2**	**2**
LDLC Testing	1	**1**	**1**	**1**	**1**
Eye Exam	1	**1**	**4**	**4**	**3**
Nephropathy Testing	1	**1**	**3**	**4**	**4**

[+] *Current Approaches to weighting include HEDIS or Minnesota Community Measurement*

Notes: IPTW: Inverse Probability Treatment Weighting, Diabetes ACSC Hospitalization: Hospitalizations for ambulatory care sensitive conditions associated with diabetes; All ACSC hospitalization: Hospitalization for all ambulatory care sensitive conditions.

CHAPTER 5: "IS QUALITY REPORTING ASSOCIATED WITH MORE CONSCIENTIOUS AMBULATORY CARE?" THE CASE OF MEDICARE'S PHYSICIAN QUALITY REPORTING SYSTEM FOR DIABETES

Objective: *To examine if reporting for diabetes measures in Medicare's Physician Quality Reporting System (PQRS) was related to more conscientious ambulatory care, we studied whether PQRS reporting for diabetes care measures was associated with better pharmacotherapy processes and ambulatory care sensitive hospitalization outcomes, among three groups of Medicare diabetics with varying intensity of PQRS reporting.*

Data and Methods: *A retrospective cohort design followed 4,720 diabetics with PQRS reporting for intermediate outcomes, 7,063 diabetics with PQRS reporting for process measures and 83,416 diabetics with no PQRS reporting from the first quarter 2009 until the end of the year. We employed ordered logistic regression to examine the association between type of reporting and number of diabetes care processes. We studied the association between type of reporting and subsequent use of angiotensin converting enzyme (ACE) / angiotensin receptor blocker (ARB) therapy, statin therapy and anti-platelet therapy by appropriate denominator diabetics employing multivariate logistic regression. We studied the association between reporting and avoidable hospitalizations & time to hospitalizations for ambulatory care sensitive conditions (ACSCs) related to diabetes and all ACSCs using multivariate logistic and cox regressions. We controlled for diabetes care processes to investigate whether the effect of reporting on subsequent processes/outcomes was mediated through diabetes care processes or through more attention to ambulatory care.*

Results: *Diabetics receiving PQRS reporting were much more likely to receive all recommended diabetes care processes than diabetics not receiving reporting (63 percent vs. 43 percent). Reporting was associated with greater likelihood of ACE/ARB and statin therapy. Reporting was associated with lesser risk and rate of diabetes ACSCs and all ACSCs. However after controlling for number of diabetes care processes, there was no effect of reporting on either pharmacotherapy or hospitalization outcomes.*

Conclusion: *Reporting was associated with a higher rate of receipt of recommended diabetes care processes. PQRS reporting was associated with better pharmacotherapy and fewer hospitalizations outcomes through these diabetes care processes, and not via more conscientious ambulatory care.*

BACKGROUND

The Centers for Medicare and Medicaid Services (CMS) have expanded their provider quality reporting initiatives beyond hospitals, skilled nursing facilities and home health agencies, to physicians. Medicare's Physician Quality Reporting System (PQRS) moved the measurement of quality of care delivered by physicians to Medicare patients beyond a limited set of claims computable process measures, to a larger set of clinically rich process and intermediate outcome measures[61].Established under the Tax Relief and Health Care Act (2006)[17], PQRS offered bonus payments to physicians who reported to CMS selected quality measures[18] for their Medicare patients from 2007. The Patient Protection

[17] The Tax Relief and Health care Act established the Physician Quality Reporting Initiative, which rechristened as PQRS from 2010

[18] To be eligible for incentive payments, physicians must report to CMS at least three PQRS quality measures for at least eighty percent of their patients who are eligible for each measure

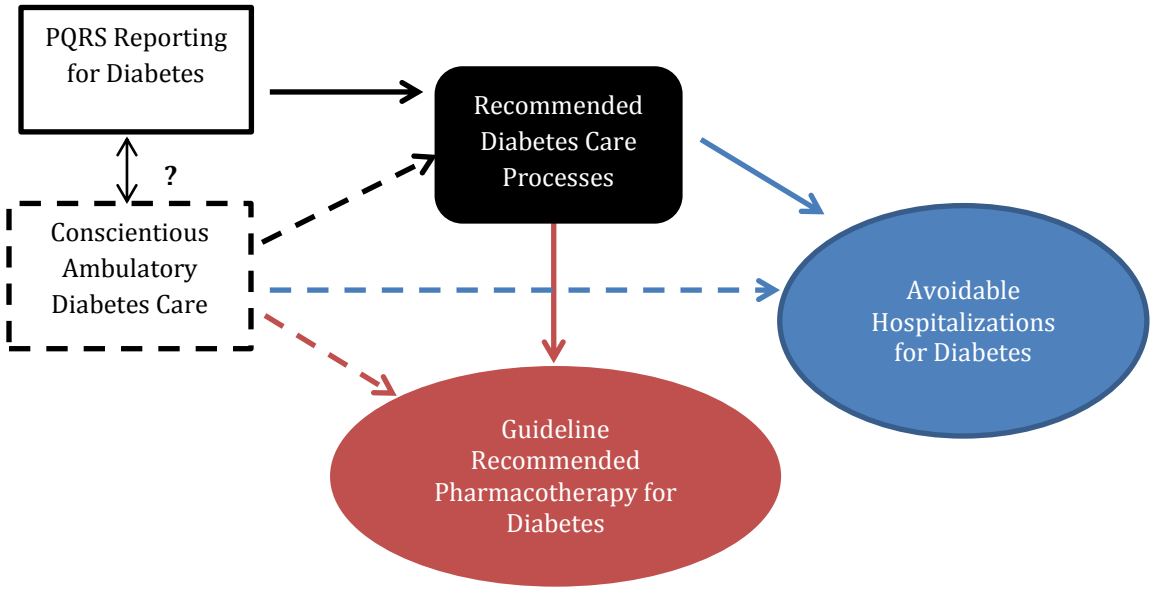
and Affordable Care Act (2010) not only extended bonus payments for reporting quality measures until 2014, but also introduced payment penalties from 2015 for physicians failing to satisfactorily report patient quality data on Medicare claims [3]. The ultimate goal of PQRS is to implement a value-based payment system that ties a proportion of physicians' future payment to higher quality and lower resource use. Encouraging reporting by physicians was the first step in this direction.

By requiring physicians to report at least 3 measures in a condition measure set (e.g. diabetes or heart failure) for at least 80 percent of eligible beneficiaries, PQRS reporting is expected to improve the receipt of recommended process measures by Medicare patients - who have been shown to often not receive recommended care. The effect of reporting on ambulatory care outcomes remains to be established. Studies on hospital quality reporting have shown minimal or no impact of reporting on outcomes [62]. One could expect physician quality reporting to be different. In the case of diabetes, patients receiving recommended care processes viz. Hemoglobin A1c (HbA1c) testing, low density lipoprotein cholesterol (LDLC) testing, and blood pressure measurement, get it due to more conscientious ambulatory diabetes care. More conscientious ambulatory care could produce better hospitalization outcomes for diabetes, although many diabetic hospitalizations are the result of years of diabetes [4]. Moreover, if this conscientiousness extended to all primary care provided, it could result in fewer ACSCs. This conceptual relationship is shown in Figure 1.

In this model conscientious care (the attention to care associated with delivering effective primary care) is a variable that we cannot assess directly. Conscientious ambulatory care consists of a set of clinical actions, observed and unobserved, provided

over time in an ambulatory care setting for effectively managing the patient's chronic conditions[11]. It may operate at two levels: 1] diabetes specific care and 2] more general primary care. The first would affect diabetes outcomes and the second ACSCs in general. Receipt of recommended diabetes care processes, guideline recommended pharmacotherapy and avoidable hospitalizations for diabetes, are all linked to conscientious ambulatory diabetes care. Processes like guideline recommended pharmacotherapy and outcomes like avoidable hospitalizations for diabetes are also linked to receipt of diabetes care processes, albeit through different mechanisms. Hence, if diabetics receiving PQRS reporting are more likely to get recommended diabetes care processes, they would also more be likely to receive guideline recommended pharmacotherapy and have fewer hospitalizations for diabetes, through diabetes care processes. We could also expect PQRS reporting and conscientious ambulatory care to be associated with each other. The causal association could be in both directions. Commitment to providing better ambulatory care might motivate physician participation in PQRS reporting. Reporting outcomes for ambulatory care processes might also motivate physicians to pay more attention to other clinical actions in this setting. If PQRS reporting remains associated with guideline recommended pharmacotherapy or hospitalization outcomes for diabetes even after controlling for care processes, then it is through its association with conscientious ambulatory care. If PQRS reporting and conscientious ambulatory care are not related, then there would be no association between reporting and guideline recommended pharmacotherapy/avoidable hospitalizations after controlling for recommended diabetes care processes.

Figure 1: Conceptual Relationship between PQRS Reporting, Conscientious Ambulatory Care, Recommended Diabetes Care Processes and Avoidable Hospitalization Outcomes & Guideline Recommended Pharmacotherapy Processes



This paper examines whether PQRS reporting for diabetes is associated with (1) greater receipt of recommended diabetes care processes (2) higher likelihood of guideline recommended pharmacotherapy and (3) lower likelihood of avoidable hospitalizations. Thereafter, we investigate whether PQRS reporting is related to conscientious ambulatory care by studying the association of reporting with guideline recommended pharmacotherapy and avoidable hospitalizations, after controlling for diabetes care processes. We use a retrospective cohort study design and identify three groups of Medicare diabetics in 2009 who differ in their level of receiving PQRS reporting: (1) those who had intermediate outcomes reported for a core set of PQRS diabetes measures- HbA1c testing and/or LDLC testing and/or BP measurement (2) those who those who had diabetes PQRS measures reported for other processes- dilated eye exams and/or attention for

nephropathy (3) those who did not receive any PQRS reporting but received recommended diabetes care processes that identifiable from administrative data. We first examine the probability of getting recommended diabetes process measures across three groups of diabetics. We then compare the likelihood of receipt of subsequent guideline recommended pharmacotherapy and likelihood of subsequent avoidable hospitalizations across these three patient groups. We finally investigate whether the association between reporting and these two sets of dependent variables is through receipt of diabetes process measures alone or also through more conscientious ambulatory care. Variation in level of reporting as well as diabetes care processes across these three groups of Medicare diabetics allows us to study whether reporting is merely associated with receipt of more diabetes care processes or also with conscientious ambulatory care.

We study the association between reporting for care processes and three subsequent guideline recommended pharmacotherapy measures. The American Diabetes Association recommends that diabetics with hypertension receive angiotensin converting enzyme (ACE) inhibitor or Angiotensin receptor blocker (ARB) therapy[11]. Clinical guidelines recommend statin therapy for diabetics over the age of 40 years and anti-platelet agents for diabetics with coronary artery disease (CAD)[11]. Prescription of anti-platelet therapy for diabetics with CAD is part of existing diabetes quality measure sets for health plans and accountable care organizations [5]. We expect that after controlling for case-mix and number of diabetes care process measures, the group of diabetics (who vary by level of reporting) who receive more conscientious ambulatory diabetes care would be more likely to get guideline recommended pharmacotherapy. We also study the association between reporting for diabetes care processes and two subsequent avoidable hospitalization

measures- hospitalizations for ambulatory care sensitive conditions associated with diabetes (diabetes ACSCs) and hospitalizations for all ambulatory care sensitive conditions (ACSCs)[45, 46, 63]. We expect that after controlling for case-mix and number of diabetes care process measures, the group of diabetics (who vary by level of reporting) receiving more conscientious ambulatory diabetes care would have fewer hospitalizations for ACSCs and diabetes ACSCs.

METHODS

DATA

We obtained Medicare claims for 199,999 beneficiaries who were seen by a nationally representative sample of 3,400 PQRS reporting or non-reporting physicians[19] in 2009. Beneficiaries were continuously enrolled in Medicare Parts A (coverage for hospital services), B (coverage for physician services), and D (coverage for prescription drugs). We obtained the 2009 beneficiary summary, MedPAR, Carrier, Outpatient, and Part D claims files for these beneficiaries.

STUDY SAMPLE

[19]The physicians were identified by their tax identification numbers (TINs). PQRS reporting and non-reporting TINs were matched by zip-code, specialty and beneficiary case-load. The beneficiaries had claims during 2009 with these TINs as well as other TINs (who could be PQRS reporting or non-reporting)

We identified beneficiaries with diabetes aged 18-75 years, who had an ambulatory care evaluation and management visit (E&M visit) within the first quarter of 2009 and were alive at the end of the year. The Chronic Condition data Warehouse (CCW) disease flag for diabetes was used to identify beneficiaries with the diabetes [48]. We excluded beneficiaries with HIV, organ transplants, active cancer treatment and end-stage-renal disease (Appendix 1) [44] . Our final study sample had a total of 95,199 beneficiaries classified into three groups based on the level of diabetes reporting that they received within the first quarter of 2009 (1) **4,720 beneficiaries with diabetes PQRS reporting for intermediate outcomes** for three measures (HbA1c testing, LDL-C testing and blood pressure testing) within the first quarter of 2009 (PQRS intermediate outcomes group), (2) **7,063 beneficiaries with diabetes PQRS reporting for process measures** for two measures (testing for nephropathy and dilated eye exams) and (3) **83,416 beneficiaries with no diabetes PQRS reporting.** Limiting our sample to beneficiaries who had E&M visits in the first quarter, allowed for equal follow-up time over the remainder of 2009 for the three beneficiary groups. We limited beneficiaries in the non-PQRS group to those who did not receive any PQRS measures during the year, for both diabetes and all other conditions. The procedure codes used to identify the diabetes intermediate outcome and process measures from Part B carrier claims are listed in Appendix 2 & Appendix 18. Since there are no procedure codes for blood pressure measurement, we used E&M visits for diabetes as a proxy for blood pressure measurement, as blood pressure measurement and treatment is an integral part of these visits. We flagged the date when PQRS and non-PQRS beneficiaries last received diabetes process measures within the first quarter of 2009- as

the treatment date. For beneficiaries who did not receive any diabetes process measure in the first quarter of 2009, the last date of the first quarter was flagged as the treatment date.

DEPENDENT VARIABLES

We examined the association between PQRS reporting and three sets of dependent variables (i) number of recommended diabetes care processes during the first quarter (ii) subsequent receipt of guideline recommended pharmacotherapy and (ii) subsequent avoidable hospitalizations.

(i) **Recommended diabetes care processes:** We identified whether beneficiaries in the three groups had received the following diabetes process measures in the first quarter of 2009: (i) HbA1c testing, (ii) LDL-C testing (iii) blood pressure measurement (iv) testing for nephropathy (v) eye exams. The procedure codes used to identify the diabetes intermediate outcome and process measures from Part B carrier claims are listed in Appendix 2. Since there are no procedure codes for blood pressure measurement, we used non-hospital evaluation and management visits for diabetes as a proxy for blood pressure measurement. We classified recommended diabetes care processes into two sets (i) core diabetes process measures: HbA1c testing, LDLC testing, and blood pressure measurement (ii) all diabetes process measures: HbA1c testing, LDLC testing, blood pressure measurement, testing for nephropathy and eye exams.

(ii) **Guideline Recommended Pharmacotherapy:** We defined use of guideline recommended pharmacotherapy after receipt of diabetes

measures as utilization of (a) ACE/ARB by diabetics with hypertension, (b) statins by diabetics over 40 years of age, and (c) anti-platelet drugs by diabetics with CAD. Beneficiaries with hypertension were identified from claims using CCW definitions. Diabetics with CAD were identified from the CCW condition flags for acute myocardial infarction and ischemic heart disease. Medicare Part D claims were used to identify utilization of ACE/ARB therapy, statin therapy, and anti-platelet therapy by beneficiaries on or after the date they received the three diabetes measures. The national drug codes for the three drug therapies are listed in Appendix 19. Utilization of drug therapy by beneficiaries was coded as a dichotomous variable.

(iii) **Avoidable hospitalizations**: We identified two sets of avoidable hospitalizations for beneficiaries from the primary diagnosis code on the hospitalization claims : (a) Hospitalization for Ambulatory Care Sensitive Conditions associated with Diabetes (Diabetes ACSCs): These were hospitalizations for complications of diabetes, uncontrolled diabetes, hypoglycemia, and hypertension [41] (b) Hospitalization for all Ambulatory Care Sensitive conditions (all ACSCs): These are a larger set of hospitalizations , defined by the Agency for Healthcare Research and Quality, that can be avoided by better ambulatory care[41, 45, 46, 63]. If beneficiaries receiving diabetes PQRS reporting received better overall ambulatory care then they might be expected to have fewer ACSCs compared to beneficiaries receiving process measure alone. The diagnoses codes and exclusions for these two hospitalization outcomes are listed in

Appendix 3. We coded both hospitalization outcomes as dichotomous variables and also calculated time to either hospitalization from the date beneficiary received diabetes measures.

STATISTICAL ANALYSES:

We compared beneficiary demographic and clinical characteristics for the three groups of beneficiaries at baseline (i.e. until treatment date) using chi-square and two sample t-tests. We studied the association between type of PQRS reporting and two sets of recommended diabetes care processes, viz. core diabetes care processes and all diabetes care processes, using ordered multivariate logistic regression. We studied the association between type of reporting and subsequent use of guideline recommended pharmacotherapy employing multivariate logistic regressions. We also used multivariate logistic regressions to evaluate the association between type of reporting and subsequent ACSC and diabetes ACSC hospitalizations. Since the rate of hospitalization over time can differ from risk of hospitalization, we examined the association between reporting and subsequent hazard of diabetes ACSC and all ACSC hospitalizations using Cox proportional hazards models. Time to event was modeled as beneficiary-month and beneficiaries were censored at the end of the year.

In all multivariate analyses, we controlled for the following beneficiary covariates: (i) **demographic characteristics:** Age, sex, race (White, Black, Hispanic, Other) , dual eligible status, rural-urban status, median zip code income and median zip code education (ii) **diabetes severity at baseline**: Type I diabetes , diabetes duration in months as measured from CCW records, insulin use and oral-anti diabetic agent use (iii)

comorbidities at baseline : 70 hierarchical condition categories (HCCs) computed using the CMS HCC model on beneficiary's claims at baseline[57].

We ran three sets of models while examining the association between reporting and subsequent guideline recommended pharmacotherapy/ avoidable hospitalizations. We incrementally controlled for diabetes care processes in these models to study whether the effect of reporting on subsequent pharmacotherapy processes/ hospitalization outcomes was mediated through diabetes care processes or provision of more conscientious ambulatory care:

Model 1: controlling for demographics characteristics, diabetes severity and comorbidities

Model 2: controlling for covariates in Model 1 & core diabetes processes- HbA1c testing, LDLC testing, and BP measurement

Model 3: controlling for covariates in model 2 and other diabetes processes- testing for nephropathy and eye exams.

All standard errors were robust in multivariate analyses. ***P*** values were 2-sided with a level of significance of ≤.05. We used SAS version 9.1[49] and STATA 12 [50] for all analyses.

RESULTS

The characteristics of diabetics receiving PQRS reporting for intermediate outcomes, PQRS reporting for processes, and no diabetes PQRS reporting at baseline are summarized in Table 1. The three groups of beneficiaries were similar in their age, gender distribution, urbanity, area income, and area education. PQRS diabetics were more likely to

be white compared to non-PQRS diabetics. Among PQRS diabetics, those receiving reporting for diabetes intermediate outcomes were more likely to be white. PQRS diabetics were more likely to have Type 1 diabetes, diabetes of longer duration, and use insulin or oral anti diabetic agents compared to non-PQRS diabetics. Among PQRS diabetics, those receiving reporting for process measures were more likely to have Type 1 diabetes and diabetes of longer duration compared to those receiving reporting for intermediate outcomes. While the distribution of comorbidities was mixed across the PQRS and non-PQRS diabetics, the HCC case mix score at baseline for the two groups were similar. The distribution of comorbidities and the case mix scores for the two groups of PQRS diabetics was also similar.

Table 2 summarizes the rate of receipt of recommended diabetes care processes among PQRS and non-PQRS diabetics. 63 percent of PQRS diabetics received all three core diabetes care processes (HbA1c/LDLC/BP measurement) while only 43 percent of the non-PQRS beneficiaries received this processes. Among PQRS diabetics, 74 percent of diabetics receiving reporting for the intermediate outcomes associated with core diabetes processes received all three care processes, while 56 percent of diabetics receiving reporting for either nephropathy/eye exams received all three core care processes. PQRS diabetics had higher rates of nephropathy testing and eye exams compared to non-PQRS diabetics. Among PQRS diabetics, those receiving reporting for intermediate outcomes had higher rates of nephropathy testing, while the latter group was more likely to receive eye exams.

Results from the multivariate ordered logistic regression predicting the likelihoods of receiving an additional core diabetes care process (HbA1c/LDLC/BP measurement) and any additional diabetes care process (HbA1c/LDLC/BP measurement/Eye Exam/Testing for Nephropathy) across PQRS and non-PQRS diabetics summarized in Table 2. Odds of

receiving an additional core diabetes process was 2.2 times higher for PQRS diabetics [95% confidence interval (CI) for odds ratio (OR): 2.1-2.3], 4.2 times higher for PQRS diabetics receiving reporting for intermediate outcomes [95% CI for OR: 3.9-4.5], and 1.5 times higher for those receiving reporting for processes [95% CI for OR: 1.4-1.6], compared to non-PQRS diabetics. The odds of receiving any additional diabetes care process was 2.8 times higher for PQRS diabetics [95% CI for OR: 2.1-2.3], 2.9 times higher for PQRS diabetics receiving reporting for intermediate outcomes [95% CI for OR: 2.8-3.0], and 2.7 times higher for those receiving reporting for processes [95% CI for OR: 2.6-2.7], compared to non-PQRS diabetics.

Results from multivariate logistic regressions predicting the likelihood of receiving guideline recommended pharmacotherapy across PQRS and non-PQRS diabetic groups is summarized in Table 3. Controlling for demographic characteristics, severity of diabetes and comorbidities, denominator diabetics receiving PQRS reporting for intermediate outcomes and reporting for processes had a significantly higher likelihood of receiving ACE/ARB therapy [Adjusted OR: 1.38 & 1.33 respectively] and statin therapy [Adj. OR: 1.42 & 1.5 respectively], compared to diabetics receiving only process measures. However after controlling for three core diabetes care processes, there was no difference in the likelihood of getting ACE/ARB therapy or statin therapy between denominator diabetics receiving PQRS reporting for intermediate outcomes and non-PQRS diabetics; while, diabetics receiving PQRS reporting for other processes had a significantly higher likelihood of ACE/ARB [Adj. OR: 1.21] and statin therapy [Adj. OR: 1.12] compared to non-PQRS diabetics. Even after controlling for the all process measures, denominator diabetics receiving PQRS reporting for other process measures had a had a significantly higher

likelihood of ACE/ARB [Adj. OR: 1.19] and statin therapy [Adj. OR: 1.08] compared to non-PQRS diabetics.

There was no difference in the likelihood of anti-platelet therapy across denominator diabetics in the three groups after controlling for demographic characteristics, severity of diabetes and comorbidities. However after controlling for number of processes, denominator diabetics receiving only process measures had significantly higher likelihood of receiving anti-platelet therapy compared to those receiving PQRS reporting for intermediate outcomes [Adj. OR: 1.19 after controlling for all diabetes processes].

Results from multivariate logistic regressions predicting the likelihood of avoidable hospitalizations, and cox regressions predicting the hazard of avoidable hospitalizations across PQRS and non-PQRS diabetic groups is summarized in Table 4. For each outcome we ran three sets of models. In the first model, we examine the effect of each level of PQRS reporting on outcome by controlling only for beneficiary characteristics that affect type of reporting and outcomes. In the second model, we control for variables in the first model as well as three core diabetes processes performed by practitioners who primarily provide diabetes care (PCPs), viz. HbA1c, LDL-C and BP measurement. Controlling for these processes allows us to see whether reporting for measures likely to be performed by PCPs has an independent relationship with the outcomes. In the third model, we control for variables in the second model as well as other diabetes processes, viz. eye exams and testing for nephropathy likely to be performed by practitioners other than PCPs, to see if reporting by practitioners other than PCPs and core processes by PCPs are related to better ambulatory care. Comparing the three models allows us to estimate whether type of

reporting remains associated with outcomes through its relationship with conscientious ambulatory care, or whether the association of reporting on outcomes is through diabetes processes alone. If the latter, we would not observe reporting to be associated with outcomes after controlling for diabetes processes in the second and third models.

There was no difference in either the likelihood or hazard of diabetes ACSC hospitalizations between diabetics receiving PQRS reporting for intermediate outcomes and non-PQRS diabetics who received diabetes process alone. Diabetics receiving PQRS reporting for processes had 34% lower risk[51] of hospitalizations for diabetes ACSCs [95% CI for relative risk (RR): 0.54-0.80] and significantly lower time to diabetes ACSC hospitalization [hazard ratio (HR): 0.67) compared to non-PQRS beneficiaries, Even after controlling for all diabetes care processes, diabetics receiving PQRS reporting for processes had significantly lower risk of diabetes ACSCs [RR(95% CI): 0.72 (0.59-0.89)] and significantly lower time to diabetes ACSCs [HR (95% CI): 0.74 (0.61-0.90)] compared to non-PQRS beneficiaries.

Diabetics receiving PQRS reporting for intermediate outcomes had 13% lower risk [51]of hospitalizations for all ACSCS [95% CI for RR: 0.70-0.95] compared non-PQRS diabetics. This difference became smaller (12% lower risk) but remained significant [95% CI for RR: 0.81-0.96] even after controlling for all process measures. But the hazard of ACSC hospitalizations was no different among these PQRS diabetics and non-PQRS diabetics. Diabetics receiving PQRS reporting for processes had 21% lower risk of hospitalizations for all ACSCS [95% CI for RR: 0.73-0.85] and significantly lower time to all ACSCs [HR (95% CI): 0.80 (0.74-0.87)] compared to non-PQRS beneficiaries. However after controlling for all

processes, there was no difference in either the likelihood or hazard of ACSC hospitalizations between diabetics receiving PQRS reporting for processes and those receiving process measures alone.

DISCUSSION

Medicare beneficiaries, who received reporting for quality measures through Medicare's Physician Quality Reporting System, received guideline recommended care processes at a rate much greater than that observed for non-reporters. Diabetics receiving PQRS reporting were more likely to receive all recommended core diabetes care processes, viz. HbA1c testing, LDL-C testing and BP measurement, than diabetics not receiving reporting (63 percent vs. 43 percent). Diabetics receiving reporting for intermediate outcomes associated with these processes (74 percent) as well as those receiving reporting for other processes. (56 percent) had higher rates care processes than non-PQRS diabetics.

Diabetics receiving PQRS reporting had higher likelihood of receiving ACE/ARB and statin therapy compared to non-PQRS diabetics. However after controlling for diabetes care processes, PQRS reporting was not associated with better ACE/ARB or statin therapy in those receiving reporting for intermediate outcomes; but was in fact found to be associated with poorer rates of statin therapy compared to non-PQRS diabetics. Hence the effect of PQRS reporting on receipt of recommended pharmacotherapy is through diabetes care processes. The effect of PQRS reporting was greater for diabetes ACSCs than all ACSCs. Diabetes ACSCs account for 24 percent of all ACSCs for diabetics, with CHF (23 percent), Asthma/COPD (22 percent) and pneumonia (14 percent) accounting for the other major ACSCs. Complications of diabetes account for 80 percent of hospitalizations for diabetes ACSCs, with hypertension (10 percent), uncontrolled diabetes (8 percent) and

hypoglycemia (2 percent) accounting for other diabetes ACSCs PQRS reporting for diabetes processes (likely to be performed by non-PCPs) was associated with lower risk and rate of diabetes ACSCs than PQRS reporting likely to be performed by PCPs. This association did not persist after controlling for diabetes care processes, suggesting that reporting was not related to conscientious ambulatory care. Reporting was related to lower risk of all ACSCs, but effect of reporting on all ACSCs did not persist when all diabetes care processes were controlled for- suggesting that the effect of reporting on this outcome was through diabetes care processes rather than conscientious ambulatory care.

In summary our study showed that PQRS reporting for diabetics was associated with greater rates of recommended diabetes care processes. The effect of reporting on guideline recommended pharmacotherapy processes and avoidable hospitalization outcomes however were through these diabetes care processes, rather than conscientious ambulatory care. The finding that diabetics who received PQRS reporting for processes had better diabetes ACSC outcomes than those who received PQRS reporting for intermediate outcomes suggests that performance of care processes may be more related to conscientious ambulatory care, rather than PQRS reporting. The differing motivations for provider participation in PQRS reporting could account for this finding. Most providers participated in PQRS reporting in 2009 for incentive payments, even though the incentive payments were not very high. Others participated in PQRS reporting to gain experience in a system that would be eventually used for future value-based payments for physicians. Commitment to a culture of quality was not the biggest motivator for provider participation in this reporting program.

The findings from our study are different from others that have shown little or no effect of quality reporting on either quality measures or outcomes [64-68]. Our study shows that PQRS reporting was associated with higher receipt of diabetes care processes, and was associated with more guideline recommended pharmacotherapy and fewer avoidable hospitalization outcomes- through these processes. Pay for performance has been shown to have a stronger effect on quality measures and outcomes than quality reporting alone[69]. The effect of PQRS reports on processes and outcomes should be expected to increase when performance on PQRS reports are tied to physician payment [70, 71].

A few limitations of this study need to be considered. We examined the association of reporting and outcomes at the patient level and not the physician level. The effect of reporting on processes and outcomes could vary by physicians who have differing motivations for participating in PQRS reporting. We studied the effect of reporting in the third year of the PQRS program. The effect of reporting on outcomes could improve over the years with physicians gain more experience in responding to feedback from reporting. But it could also be argued that outcomes are not likely to improve if early adopters are physicians who are more motivated by quality. Secondly, due to constraints imposed by our data, we only examined the effect of reporting on outcomes in the short-run, i.e. within the year. The effect of reporting on outcomes could be more pronounced in the long-run, especially given that reporting was found to be associated with higher guideline recommended medication use. We used E&M visit for diabetes as a proxy for blood pressure measurement process for diabetics who did not receive PQRS reporting for blood pressure. The true rate of blood pressure measurement may be higher for non-PQRS diabetics and diabetics with PQRS reporting for processes. This measurement error is in the direction of

our finding that reporting leads to better processes and outcomes, and against the direction of our finding that the effect of reporting on outcomes is mainly through diabetes care processes. Our measure of anti-platelet therapy included aspirin and other anti-platelet agents. But given that aspirin can be procured over the counter- our measure of anti-platelet therapy obtained from Medicare claims is lower than the true measure. Finally, diabetics in our sample had at least one E&M visit during the first quarter of 2009, and were hence more likely to be higher utilizers of care than the average Medicare diabetics.

CONCLUSION

Even as PQRS inches towards its goal of motivating Medicare physicians across the board to report quality measures through incentive payments or penalties, we find in our study that PQRS reporting was associated with greater receipt of care processes for Medicare beneficiaries. But reporting was not indicative of more conscientious ambulatory care and was associated with better recommended pharmacotherapy and fewer hospitalization outcomes only through care processes. Given that the ultimate goal of the PQRS program is to facilitate the creation of a system that rewards more conscientious ambulatory care by employing its wealth of quality measures – the value of this reporting program would be further realized in the near future.

Table 5.1: Characteristics of beneficiaries receiving Diabetes PQRS measures and No Diabetes PQRS measures in 2009

Total Beneficiary Sample=95,199	**Diabetics with PQRS Reporting**	Diabetics with PQRS Reporting for Intermediate Outcomes	Diabetics with PQRS Reporting for Processes	**Diabetics with No PQRS Reporting**
	N=11,783	N=4,720	N=7,063	**N=83,416**
DEMOGRAPHICS				
Age	**66.1 (9.0)***	65.7(9.3)#	66.4(8.5)#	**65.1(9.7)***
Female	**60.0%**	59.3%#	61.9%#	**60.9%**
White	**80.9%***	84.8%#	78.3%#	**76.2%***
Black	**12.4%***	10.9%#	13.5%#	**14.6%***
Hispanic	**3.0%***	1.6%#	3.8%#	**3.9%***
Other	**3.7%***	2.6%#	4.4%#	**5.3%***
Median Income	**$42,647(1,562)***	$43,343(1,542)#	$42,182(1,574)#	**$41,396(1,603)***
Median Education in Years	**13.2(1.1)***	13.3(1.0)#	13.1(1.2)#	**13.1(1.2)***
Rural	**6.2%**	5.9%	6.5%	**5.9%**
Diabetes				
Type I Diabetes	**18.5%***	17.0%#	21.4%#	**11.4%***
Diabetes Duration in Months	**63.7(39.3)***	62.3(39.8)#	64.7(39.7)#	**52.3(40.9)***
Insulin at Baseline	**22.30%***	21.5%	22.9%	**14.40%***
Oral Anti Diabetics at Baseline	**31.8%***	32.0%	31.7%	**24.8%***

Total Beneficiary Sample=95,199	Diabetics with PQRS Reporting	Diabetics with PQRS Reporting for Intermediate Outcomes	Diabetics with PQRS Reporting for Processes	Diabetics with No PQRS Reporting
	N=11,783	N=4,720	N=7,063	**N=83,416**
COMORBIDITIES				
Hypertension	**77.80%***	77.8%	77.9%	**74.9%***
Coronary Artery Disease	**51.7%***	50.7%	52.4%	**47.0%***
Atrial Fibrillation	**8.5%**	8.9%	8.1%	**8.5%**
Dementia	**7.2%***	6.7%	7.4%	**10.1%***
Chronic Kidney Disease	**30.9%***	31.6%	30.5%	**26.3%***
COPD	**17.2%***	18.4%#	16.5%#	**21.6%***
Congestive Heart Failure	**28.0%***	28.1%	28.0%	**30.0%***
Depression	**24.3%***	26.3%#	23.0%#	**28.4%***
Stroke	**6.5%***	6.3%	6.6%	**7.8%***
Cancer	**6.6%***	7.1%	6.2%	**7.2%***
Baseline HCC SCORE	**0.74(0.67)***	0.75(0.67)	0.73(0.67)	**0.79(0.77)***

** Differences between PQRS and Non-PQRS diabetics significant at P<0.05 # Differences between diabetics receiving PQRS reporting for intermediate outcomes and PQRS reporting for processes significant at P<0.05.*

Notes: PQRS Reporting for Intermediate Outcomes: HbA1c testing, LDLC testing, BP measurement; PQRS Reporting for Processes: Testing for Nephropathy, Eye Exams; COPD: Chronic Obstructive Pulmonary Disease: HCC Score: Hierarchical Conditions Categories Case Mix Score.

Table 5.2: Rate of Diabetes Care Processes among PQRS and Non-PQRS Diabetics in 2009 and Adjusted Odds ratio for getting Diabetes Care Processes

	Diabetics with PQRS Reporting	Diabetics with PQRS Reporting for Intermediate Outcomes	Diabetics with PQRS Reporting for Processes	**Diabetics with No PQRS Reporting**
	N=11,783	N=4,720	N=7,063	**N=83,416**
CORE DIABETES CARE PROCESSES (HbA1c/LDLC/BP Measurement)				
3 Measures	**63%***	74%#	56%#	**43%***
2 Measures	**15%***	13%#	17%#	**21%***
1 Measure	**15%***	13%#	16%#	**14%***
None	**7%***	0%#	11%#	**22%***
OTHER DIABETES CARE PROCESSES				
Testing for Nephropathy	**65%***	67%#	63%#	**57%***
Eye Exam	**79%***	66%#	87%#	**54%***
Adj. OR for Any Core Diabetes Process	2.22(2.13-2.31)*	4.20 (3.92-4.49)*#	1.52(1.45-1.60)*#	Reference
Adj. OR for Any Diabetes Process	2.79(2.70-2.90)*	2.92 (2.77-3.01)*#	2.70 (2.60-2.73)*#	Reference

** Differences between PQRS and Non-PQRS diabetics significant at P<0.05 # Differences between diabetics receiving PQRS reporting for intermediate outcomes and PQRS reporting for processes significant at P<0.05.Notes: PQRS Reporting for Intermediate Outcomes: HbA1c testing, LDLC testing, BP measurement; PQRS Reporting for Processes: Testing for Nephropathy, Eye Exams.*

Table 5.3 Adjusted Odds Ratio for Subsequent Guideline Recommended Pharmacotherapy for PQRS Diabetics

	Covariates Controlled For	Diabetics with PQRS Reporting for Intermediate Outcomes	Diabetics with PQRS Reporting for Processes
GUIDELINE RECOMMENDED PHARMACOTHERAPY		*Adjusted Odds Ratio (95% CI)*	
ACE/ARB Therapy (with Hypertension)	Demographics+Severity of Diabetes+Comorbidities	1.38(1.26-1.51)*****	1.33(1.23-1.43)*****
	+HbA1c+LDLC+BP	1.07 (0.97-1.18)	1.21(1.17-1.30)*****
	+Eye+Nephro	1.07(0.97-1.17)	1.19(1.10-1.29)*
Statin Therapy (Age>40 years)	Demographics+Severity of Diabetes+Comorbidities	1.42(1.31-1.54)*****	1.25(1.17-1.33)*****
	+HbA1c+LDLC+BP	1.06(0.98-1.15)	1.12(1.05-1.19)*****
	+Eye+Nephro	1.05(0.97-1.14)	1.08(1.01-1.15)*
Anti-Platelet Therapy (with Coronary Artery Disease)	Demographics+Severity of Diabetes+Comorbidities	0.94(0.83-1.07)	1.03(0.93-1.14)
	+HbA1c+LDLC+BP	0.84(0.74-0.96)*	0.99(0.89-1.10)
	+Eye+Nephro	0.84(0.74-0.96)*	1.03(0.93-1.14)

** Differences between PQRS and Non-PQRS diabetics significant at P<0.05 Notes: PQRS Reporting for Intermediate Outcomes: HbA1c testing, LDLC testing, BP measurement; PQRS Reporting for Processes: Testing for Nephropathy, Eye Exams*

Table 5.4 Adjusted Relative Risk and Adjusted Hazard Ratio for Diabetes ACSC Hospitalizations and All ACSC Hospitalizations for PQRS Diabetics

	Covariates Controlled For	Diabetics with PQRS Reporting for Intermediate Outcomes	Diabetics with PQRS Reporting for Processes
		Adjusted Relative Risk or Hazard Ratio (95% CI)	
LIKELIHOOD OF DIABETES ACSC HOSPITALIZATIONS	Demographics+Severity of Diabetes+Comorbidities	1.11 (0.91-1.35)	0.66 (0.54-0.80)*
	+HbA1c+LDLC+BP Processes	0.94 (0.77-1.14)	0.62 (0.51-0.76)*
	+Eye+Nephro Processes	0.96 (0.78-1.17)	0.72 (0.59-0.89)*
HAZARD OF DIABETES ACSC HOSPITALIZATIONS	Demographics+Severity of Diabetes+Comorbidities	1.10 (0.91-1.32)	0.67 (0.55-0.81)*
	+HbA1c+LDLC+BP Processes	0.96 (0.79-1.16)	0.64 (0.52-0.77)*
	+Eye+Nephro Processes	0.98 (0.81-1.19)	0.74 (0.61-0.90)*
LIKELIHOOD OF ALL ACSC HOSPITALIZATIONS	Demographics+Severity of Diabetes+Comorbidities	0.87(0.70-0.95)*	0.79 (0.73-0.85)*
	+HbA1c+LDLC+BP Processes	0.87(0.80-0.95)*	0.79 (0.74-0.85)*
	+Eye+Nephro Processes	0.88(0.81-0.96)*	0.93 (0.87-1.01)
HAZARD OF ALL ACSC HOSPITALIZATIONS	Demographics+Severity of Diabetes+Comorbidities	0.91(0.83-1.00)	0.80 (0.74-0.87)*
	+HbA1c+LDLC+BP Processes	0.93(0.84-1.02)	0.80 (0.74-0.87)*
	+Eye+Nephro Processes	0.94(0.85-1.04)	0.94 (0.86-1.02)

** Differences between PQRS and Non-PQRS diabetics significant at P<0.05 Notes: PQRS Reporting for Intermediate Outcomes: HbA1c testing, LDLC testing, BP measurement; PQRS Reporting for Processes: Testing for Nephropathy, Eye Exams*

CHAPTER 6: CONCLUSIONS

This study found two of the current practices in measurement of quality of diabetes care to be inapt for Medicare beneficiaries with diabetes. While our study focused on diabetes care, these findings apply to quality of care for other chronic conditions managed in ambulatory care settings as well.

THE ALL-OR-NONE APPROACH: SIMPLE IS *NOT* BETTER

The all-or-none approach to diabetes care quality measurement, currently employed in *Medicare's ACO demonstration*, is unsuitable for measurement of quality of care for chronic conditions- where multiple care components vary in their relative importance. In Chapter 3, we found that this approach has poor predictive validity, discards meaningful & important quality information and has low discrimination for the Medicare population. Most Medicare beneficiaries, who are unlikely to get all recommended care measures, would be classified as failures in meeting the quality bar, using this approach. The approach also has poor reliability, lacking the sensitivity for distinguishing between physicians and plans. This approach may be more suited for evaluating multistep processes of care, e.g. diagnosis and treatment of pneumonia, where each step is vital for a successful outcome. But it is definitely not suited for measuring quality of diabetes care or other chronic conditions [4].

EQUAL WEIGHTING OF MEASURES: SOME MEASURES ARE MORE EQUAL

Our findings in Chapter 4 challenge the approach intended to be used for quality measurement in *Medicare's Physician Value-Based Modifier*. The proposed approach, equally weights all measures in the diabetes measure set even when they are not equally important

for quality of diabetes care. We found that while physician quality leaders endorsed this dogma, measures like HbA1c and LDL-C measurement were more strongly related to quality of diabetes care- than eye exams or testing for nephropathy.

As acknowledged by the National Quality Forum, consensus drives every aspect of quality measurement work in practice today. Quality measures chosen for conditions are rarely exclusively based on evidence from RCTs. The temptation to ensure that measures in a disease measure set cover all important aspects of care for the disease – motivates the addition of guideline-based measures alongside evidence-based measures. Assigning measures in the composite equal weight ensues from the temptation to keep measurement simple. This not only dilutes the association of the measure set with the quality, but also propagates inefficiencies in the healthcare system when processes of care that truly do not add value to patients are performed by providers. Eye exams and testing for nephropathy are examples of such guideline-based measures. Monitoring progress of retinopathy and nephropathy annually is important in diabetics who have early stages of retinopathy and nephropathy respectively. Annual testing for retinopathy and nephropathy is not as important in other diabetics as annual HbA1c and LDL-C testing. Equally weighting all four measures would be justified only if the denominator population for eye exams and testing for nephropathy were limited to diabetics with some form of retinopathy or nephropathy.

Our study found that ambulatory care process measures related and unrelated to diabetes were explained by a single underlying factor. Viewing measures as causes or effects of quality has different implications for how physicians and policy makers approach quality improvement [23]. If measures are believed to cause quality- which might be unobserved, or observed as outcomes, then quality improvement efforts should be focused

on improving measures to have its desired effect [23]. If measures are in fact effects of the underlying quality construct, then quality improvement efforts should be focused on improving the quality culture of ambulatory care practice. Focusing quality improvement efforts at the level of measures, in this case, would not result in any quality improvement [23].

Quality Reporting: Improving Recommended Care Processes

Medicare beneficiaries often do not receive recommended processes of care. In Chapter 5, we found that Medicare beneficiaries who received PQRS reporting received recommended care processes at a much higher rate than beneficiaries who received process measures alone. It would be fair to conclude that PQRS reporting has succeeded in improving recommended measure rates among Medicare beneficiaries. Diabetics who received PQRS reporting had higher rates of clinical action measures like receipt of guideline recommended pharmacotherapy processes. They also had better outcomes, in the form of fewer avoidable hospitalizations. But reporting was not indicative of more conscientious ambulatory care and was associated with better recommended pharmacotherapy and fewer hospitalization outcomes only through care processes. Given that the ultimate goal of the PQRS program is to facilitate the creation of a system that rewards more conscientious ambulatory care by employing its wealth of quality measures – the value of this reporting program should be further realized in the near future.

Future Of Diabetes Quality Measurement

Improving the future of diabetes quality measurement requires us to better link ambulatory diabetes care to consequences of care- viz. clinical actions and patient outcomes. In this dissertation we linked diabetes care to clinical actions such as receipt of

guideline recommended pharmacotherapy, as well as outcomes such as hospitalizations for diabetes ACSCs. Medicare's physician value-based modifier payment system has already incorporated pharmacotherapy and hospitalization outcomes measures in their measurement of care quality. Evolving technology, including use of electronic health records should allow us to incorporate richer clinical action measures and patient reported health outcomes to diabetes performance measurement, than what is limitedly available now through claims and registries.

Finally, it is important to recognize that true quality of ambulatory care is unseen- we only observe some of its indicators. Essential components of quality such as provider communication and proactivity remain unmeasured. Quality is in a state of constant flux for a patient - patient preferences change along with their health status, from changing clinical care & its varying consequences. The models of quality measurement that we use in our quest for quality improvement need to appreciate the nature of this variable, so that we can measure it better. The latent variable approach to measuring quality of care succeeds in this regard. Future research in quality measurement to be to be undertaken include latent growth modeling to capture effects of care continuity and care coordination on the quality construct, as well as multiple-group factor analysis to study how latent quality differs by providers.

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APPENDICES

APPENDIX 1: CODES TO IDENTIFY BENEFICIARIES WITH HIV, ACTIVE CANCER TREATMENT, ORGAN TRANSPLANT AND END-STAGE RENAL DISEASE FOR EXCLUSION

Condition	Codes
HIV	ICD-9 diagnosis code: 042
Active Cancer Treatment	ICD-9 diagnosis codes: 140-208, 230-23 ; ICD-9 procedure codes: 41.0, 41.91, 92.2; CPT codes: 38230, 38240-38242, 77261-77799, 79000-79999, 96400-96549
Organ Transplant	ICD-9 procedure codes: 33.5, 33.6, 37.5, 41.94, 46.97, 50.5, 52.8, 55.6; CPT codes: 32850-32856, 33930-33945, 44132-44137, 44715-44721, 47133-47147, 48160, 48550-48556, 50300-50380; HCPCS codes: S2152, S2053-S2055, S2060, S2061, S2065
End-Stage Renal Disease	ICD-9 diagnosis codes:585.5, 585.6, V42.0, V45.1, V56; ICD-9 procedure codes: 38.95, 39.27, 39.42, 39.43, 39.53, 39.93, 39.94, 39.95, 54.98; CPT codes: 36145, 36800-36821, 36831-36833, 90919-90921, 90923-90925, 90935, 90937, 90939, 90940, 90945, 90947, 90989, 90993, 90997, 90999, 99512 ; HCPCS codes: G0257, G0311-G0319, G0321-G0323, G0325-G0327, G0392, G0393, S9339

APPENDIX 2: CODES TO IDENTIFY DIABETES CARE PROCESSES, AMBULATORY CARE PROCESSES AND SEVERITY OF DIABETES VARIABLES

Measure/Variable	Codes
Diabetes Care Processes	
HbA1c Testing	CPT codes: 83036, 83037, 3044F, 3045F, 3046F, and 3047F
LDLC Testing	CPT codes: 80061, 83700, 83701, 83704, 83715, 83716, 83721, 3048F, 3049F, and 3050F
Dilated Eye Exams	CPT codes: 67028, 67030, 67031, 67036, 67038, 67039, 67040, 67101, 67105, 67107, 67108, 67110, 67112, 67121, 67141, 67145, 67208, 67210, 67218, 67220, 67221, 67227, 67228, 92002, 92004, 92012, 92014, 92018, 92019, 92225, 92226, 92230, 92235, 92240, 92250, ,92260, 2022F, 2024F, 2026F, and 3072F
Testing for Nephropathy	CPT codes: 81000, 81001, 81002, 81003, 81005, 82042, 82043, 82044, 84156, 3060F, 3062F and 3061F
Evaluation & Management (E&M) Visit for Diabetes	Berenson-Eggers type of service (BETOS) codes: M1A and M1B with ICD-9 diagnosis codes:249.00, 249.01, 249.10, 249.11, 249.20, 249.21, 249.30, 249.31, 249.40, 249.41, 249.50, 249.51, 249.60, 249.61, 249.70, 249.71, 249.80, 249.81, 249.90, 249.91, 250.00, 250.01, 250.02, 250.03, 250.10, 250.11, 250.12, 250.13, 250.20, 250.21, 250.22, 250.23, 250.30, 250.31, 250.32, 250.33, 250.40, 250.41, 250.42, 250.43, 250.50, 250.51, 250.52, 250.53, 250.60, 250.61, 250.62, 250.63, 250.70, 250.71, 250.72, 250.73, 250.80, 250.81, 250.82, 250.83, 250.90, 250.91, 250.92, 250.93, 357.2, 362.01, 362.02, and 366.41
Diabetes Program	CPT codes: 97802, 97803, 97804 , G0108, G0109, G0270, and G0271
Ambulatory Care Processes	
Influenza Vaccination	CPT codes: 90724, 90658, 90659, 90656 ,and G0008
Breast/Prostate Cancer Screening	CPT codes: 77057, G0202, 84153, and G0103 or ICD-9 diagnosis codes: V7612, and V7644
Severity of Diabetes	
Type 1 Diabetes	ICD-9 diagnosis codes: 250.01, 250.03, 250.11, 250.13, 250.21, 250.23, 250.31, 250.33, 250.41, 250.43, 250.51, 250.53, 250.61, 250.63, 250.71, 250.73, 250.81, 250.83, 250.91, and 250.93
Self-Monitoring of Blood Glucose	CPT/HCPCS Code on Carrier/Durable Medical Equipment Claims: 82962, A4253, A4256, A4258, A4259,E0607, E2100, E2101,
Insulin Pump Use**	CPT/HCPCS Code on Carrier/Durable Medical Equipment Claims: E0781, E0784, A4231, A4230, K0552, S5565, S5566, A4221, J1815, J1816, J1817, A4632, K0601, K0602, K0605, A4365, A5120, A4245, A4247, A6257, A6258, A4364, A4450, A9274

*** Medicare Part B covers insulin pumps, while Medicare Part D covers insulin taken in the injectable form.*

APPENDIX 3: CODES TO IDENTIFY HOSPITALIZATIONS FOR AMBULATORY CARE SENSITIVE CONDITIONS (ACSCS) AND ACSCS ASSOCIATED WITH DIABETES

ACSC Hospitalization	Codes
Diabetes Complications**	All discharges with principal ICD-9 diagnosis codes: Diabetes Short term Complications: 250.10, 250.11, 250.12,250.13, 250.20, 250.21, 250.22,250.23, 250.30, 250.31, 250.32, and 250.33; or Diabetes Long term Complications: 250.40, 250.41, 250.42,250.43, 250.50, 250.51, 250.52,250.53, 250.60, 250.61, 250.62,250.63, 250.70, 250.17, 250.72,250.73, 250.80, 250.81, 250.82,250.83, 250.90, 250.91, 250.92, and 250.93.
Uncontrolled Diabetes**	All discharges with principal ICD-9 diagnosis codes: 250.02 and 250.03
Hypoglycemia**	All discharges with principal ICD-9 diagnosis codes: 251.2, and 251.20 with accompanying secondary ICD-9 diagnosis codes: 250.x0, 250.x1, 250.x2 and 250.x3.
Hypertension**	All discharges with principal ICD-9 diagnosis codes: 410.0, 401.9, 402.00, 402.10, 402.90, 403.00, 403.10, 403.90, 404.00, 404.10, and 404.90. Exclude cases with a cardiac procedure code. *Exclude cases with any diagnosis code for Stage I-IV kidney disease and accompanying procedure code for hemodialysis.*
Chronic Obstructive Pulmonary Disease	All discharges with principal ICD-9 diagnosis codes: 466.0*, 490*, 491.0, 491.1, 491.20, 491.21, 491.8, 491.9, 492.0, 492.7, 494, 494.0, 494.1, and 496 *. Qualifies only if accompanied by secondary diagnosis of 491.xx, 492.x, 494.x, or 496.
Congestive Heart Failure	All discharges with principal ICD-9 diagnosis codes: 398.91, 428.0, 428.1, 428.20, 428.21, 428.22, 428.23, 428.30, 428.31, 428.32, 428.33, 428.40, 428.41, 428.42, 428.43, and 428.9. *Exclude cases with cardiac procedure code.*
Dehydration	All discharges with principal ICD-9 diagnosis codes: 276.5, 276.50, 276.51, and 276.52; OR All discharges with Secondary ICD-9 diagnosis codes: 276.5, 276.50, 276.51, and 276.52 with accompanying Principal ICD-9 diagnosis codes: 276.0, 008.6x, 008.8, 009.0, 009.1, 009.2, 009.3, 558.9, 584.5, 584.6, 584.7, 584.8, 586, and 997.5. *Exclude cases with any diagnosis code for chronic renal failure.*
Bacterial Pneumonia	All discharges with principal ICD-9 diagnosis codes: 481, 482.2, 482.30, 482.31, 482.32, 482.39, 482.41, 484.42, 482.9, 483.0, 483.1, 483.8, 485, and 486. *Exclude cases with any diagnosis code of sickle cell anemia or HB-S disease. Exclude cases with any diagnosis or procedure code for immunocompromised state.*
Urinary Tract Infection	All discharges with principal ICD-9 diagnosis codes: 590.10, 590.11, 590.2, 590.3, 590.80, 590.81, 590.9, 595.0, 595.9, and 599.0. *Exclude cases with any diagnosis of kidney/urinary tract disorder. Exclude cases with any diagnosis or procedure code for immunocompromised state.*

ACSC Hospitalization	Codes
Angina without Procedure	All discharges with principal ICD-9 diagnosis codes: 411.1, 411.81, 411.89, 413.0, 413.1 and 413.9. *Exclude cases with a cardiac procedure code.*
Adult Asthma	All discharges with principal ICD-9 diagnosis codes: 493.00, 493.01, 493.02, 493.10, 493.11, 493.12, 493.20, 493.21, 493.22, 493.81, 493.82, 493.90, 493.91 and 493.92. *Exclude cases with any diagnosis code of cystic fibrosis and anomalies of the respiratory system.*

*****ACSCs associated with Diabetes***

Conditions for ACSC Exclusions	Codes
Trauma	ICD-9 diagnosis codes: 895.0, 895.1, 896.0, 896.1, 896.2, 896.3, 897.0, 897.1, 897.2, 897.3, 897.4, 897.5, 897.6, and 897.7.
Cardiac Procedures	ICD-9 procedure codes: 005.1, 005.2, 0053, 005.4, 005.6, 005.7, 006.6, 175.1, 175.2, 175.5, 350.0, 350.1, 350.2, 350.3, 350.4, 350.5, 350.6, 350.7, 350.8, 350.9, 351.0, 351.1, 351.2, 351.3, 351.4, 352.0, 352.1, 352.2, 352.3, 352.4, 352.5, 352.6, 352.7, 352.8, 353.1, 353.2, 353.3, 353.4, 353.5, 353.9, 354.1, 354.2, 355.0, 355.1, 355.2, 355.3, 355.4, 355.5, 356.0, 356.1, 356.2, 356.3, 357.0, 357.1, 357.2, 357.3, 358.1, 358.2, 358.3, 358.4, 359.1, 359.2, 359.3, 359.4, 359.5, 359.6, 359.8, 359.9, 360.1, 360.2, 360.3, 360.4, 360.5, 360.6, 360.7, 360.9, 361.0, 361.1, 361.2, 361.3, 361.4, 361.5, 361.6, 361.7, 361.9, 362, 363, 363.1, 363.2, 363.3, 363.4, 363.9, 369.1, 369.9, 373.1, 373.2, 373.3, 373.4, 373.5, 373.6, 374.1, 375 , 375.1, 375.2, 375.3, 375.4, 375.5, 376.0, 376.1, 376.2, 376.3, 376.4, 376.5, 376.6, 377.0, 377.1, 377.2, 377.3, 377.4, 377.5, 377.6, 377.7, 377.8, 377.9, 378.0, 378.1, 378.2, 378.3, 378.5, 378.6, 378.7, 378.9, 379.4, 379.5, 379.6, 379.7, 379.8, and 382.6
Stage I-IV Kidney Disease with Hemodialysis	ICD-9 diagnosis codes: 403.00, 403.10, 403.90, 404.00, 404.10, and 404.90 with accompanying ICD-9 procedure codes: 389.5, 392.7, 392.9, 394.2, 399.3, and 399.4.
Chronic Renal Failure	ICD-9 diagnosis codes: 403.00, 403.01, 403.10, 403.11, 403.90, 403.91, 404.00, 404.01, 404.02, 404.03, 404.10, 404.11, 404.12, 404.13, 404.90, 404.91, 404.92, 404.93, 585, 585.5 , and 585.6
Sickle Cell Anemia or HB-S	ICD-9 diagnosis codes: 282.41, 282.42, 282.60, 282.61, 282.62, 282.63, 282.64, 282.68, and 282.69
Immunocompromised States	ICD-9 diagnosis codes: 042, 136.3, 199.2,238.73, 238.76, 238.77, 238.79, 260 ,261, 262 , 279.00, 279.01 , 279.02, 279.03, 279.04, 279.05, 279.06, 279.09, 279.10, 279.11, 279.12, 279.13 ,279.19 ,279.2, 279.3, 279.4, 279.41, 279.49, 279.50, 279.51, 279.52, 279.53, 279.8, 279.9, 284.09, 284.1, 284.11, 284.12 , 284.19, 288.0, 288.00, 288.01, 288.02, 288.03, 288.09, 288.1 , 288.2, 288.4 , 288.50, 288.51, 288.59 , 28953, 289.83, 403.01, 403.11, 403.91, 404.02, 404.03, 404.12, 404.13, 404.92, 404.93, 579.3, 585 , 585.5 , 585.6, 996.8, 996.80, 996.81, 996.83, 996.84,

Conditions for ACSC Exclusions	Codes
	996.85, 996.86, 996.87, 996.88, 996.89, V42.0, V42.1, V42.6, V42.7, V42.8, V42.81, V42.82, V42.83, V42.84, V42.89, V45.1 , V45.11, V56.0 , V56.1, and V56.2; OR ICD-9 procedure codes: 335, 335.0, 335.1,335.2, 336, 375, 375.1, 410, 410.0, 410.1, 410.2, 410.3, 410.4, 410.5, 410.6, 410.7, 410.8, 410.9, 505.1, 505.9, 528.0, 528.1, 528.2, 528.3, 528.5, 528.6, and 556.9.
Kidney/Urinary Tract Disorder	ICD-9 diagnosis codes: 590.00, 590.01, 593.70, 593.71, 593.72, 593.73, 753.0 , 753.10, 753.11, 753.12, 753.13, 753.14, 753.15, 753.16, 753.17, 753.19, 753.20, 753.21, 753.22, 753.23, 753.29, 753.3 , 753.4, 753.5 ,753.6, 753.8 , and 753.9.
Cystic Fibrosis and Anomalies of the Respiratory System	ICD-9 diagnosis codes: 277.00, 277.01, 277.02, 277.03, 277.09, 747.21, 748.3, 748.5, 748.60, 748.61, 748.69, 748.8, 748.9, 750.3, 759.3, and 770.7

APPENDIX 4: MULTIVARIATE LOGISTIC REGRESSION PREDICTING THE LIKELIHOOD OF HOSPITALIZATION FOR DIABETES AND ALL AMBULATORY CARE SENSITIVE CONDITIONS (ACSC) IN 2007 BASED ON DIABETES CARE PROCESSES IN 2006 : ZERO, ONE , TWO THREE VS. ALL

	Diabetes ACSC Hospitalizations in 2007		ACSC Hospitalizations in 2007	
	Odds Ratio	***95% CI of Odds Ratio***	***Odds Ratio***	***95% CI of Odds Ratio***
Diabetes Care Processes				
Zero vs. All	2.19**	1.78-2.69	1.62**	1.51-1.75
One vs. All	1.64**	1.37-1.97	1.50**	1.41-1.60
Two vs. All	1.35**	1.16-1.58	1.24**	1.17-1.32
Three vs. All	1.16	1.00-1.35	1.05	0.99-1.11
Diabetes ACSC/All ACSC in 2006	5.4**	3.65-7.99	2.89**	2.51-3.33
Demographics				
Age (Reference: <60 years)				
60-64 years	0.71	0.43-1.16	0.87	0.69-1.08
65-69 years	0.64	0.26-1.55	0.78	0.56-1.07
70-75 years	0.60	0.24-1.50	0.78	0.57-1.07
Female vs. Male	0.74	0.53-1.03	1.19	1.07-1.35
Race (Reference: White)				
Black	1.8**	1.14-2.70	1.04	0.89-1.22
Other	0.74	0.35-1.57	0.84	0.65-1.08
Median Zip code Income	1.00	0.99-1.00	0.99	0.99-1.00
Median Zip code Education (years)	0.82	0.61-1.10	0.97	0.90-1.04
Dual vs. Non Dual	1.41	0.93-2.14	1.21**	1.06-1.38
Severity of Diabetes				
Type 1 vs. Type 2	1.66**	1.28-2.15	1.2**	1.09-1.32
Insulin vs. No Insulin	1.41	0.66-2.99	1.28	0.89-1.83
Self-Monitoring Blood Glucose	1.12	0.77- 1.61	0.89**	0.78-0.99
Diabetes Duration in Years	1.17**	1.09- 1.25	1.06**	1.03-1.09
Selected HCCs				
HCC15:Diabetes with Renal/Circulatory Manifestation	2.72**	1.61-4.62	1.19**	1.01-1.41
HCC16:Diabetes with Neurologic/Other Manifestation	3.17**	1.99-5.06	1.31**	1.12-1.54
HCC32:Pancreatic Disease	2.7**	1.46-4.99	1.23	0.91-1.65
HCC54: Schizophrenia	0.51**	0.30-0.86	0.60**	0.47-0.77
HCC55:Major Depressive, Bipolar, and Paranoid Disorders	0.87	0.56-1.34	1.04	0.85-1.26

	Diabetes ACSC Hospitalizations in 2007		ACSC Hospitalizations in 2007	
	Odds Ratio	***95% CI of Odds Ratio***	***Odds Ratio***	***95% CI of Odds Ratio***
HCC70:Muscular Dystrophy	0.08**	0.01-0.61	0.54	0.10-2.76
HCC71: Polyneuropathy	1.1	0.86-1.39	1.02	0.88-1.19
HCC77: Respirator Dependence	3.14**	1.29-7.61	0.73	0.51-1.38
HCC80: Congestive Heart Failure	1.00	0.67-1.49	1.65**	1.46-1.89
HCC81: Acute Myocardial Infarction	0.27**	0.16-0.48	1.12	0.85- 1.50
HCC82: Unstable Angina and Ischemic Heart Disease	1.43	0.67- 3.08	1.30**	1.04-1.62
HCC95: Cerebral Hemorrhage	3.66**	1.70-7.89	1.36	0.79-2.34
HCC96: Ischemic or Unspecified Stroke	1.27	0.89-1.80	1.17	0.98-1.41
HCC100: Hemiplegia/Hemiparesis	0.46**	0.26-0.82	1.01	0.76-1.35
HCC104: Vascular Disease with Complications	0.54	0.68-1.27	1.00	0.80-1.25
108: Chronic Obstructive Pulmonary Disease	0.83	0.49-1.40	2.05**	1.80-2.32
HCC111: Aspiration and Specified Bacterial Pneumonias	0.35**	0.15-0.85	1.25	0.92-1.70
HCC119: Proliferative Diabetic Retinopathy and Vitreous Hemorrhage	1.56**	1.12-2.18	1.30**	1.06-1.60
HCC131: Renal Failure	1.45**	1.02-2.07	1.24**	1.08-1.43

*** OR significant at P<0.05*

APPENDIX 5: MULTIVARIATE LOGISTIC REGRESSION PREDICTING THE LIKELIHOOD OF HOSPITALIZATION FOR DIABETES AND ALL AMBULATORY CARE SENSITIVE CONDITIONS (ACSC) IN 2007 BASED ON DIABETES CARE PROCESSES IN 2006 –ONE, TWO, THREE, FOUR VS. ZERO

	Diabetes ACSC Hospitalizations in 2007		ACSC Hospitalizations in 2007	
	Odds Ratio	*95% CI of Odds Ratio*	*Odds Ratio*	*95% CI of Odds Ratio*
Diabetes Care Processes				
One vs. Zero	0.75**	0.61-0.92	0.92**	0.86-0.99
Two vs. Zero	0.61**	0.51-0.74	0.76**	0.71-0.82
Three vs. Zero	0.55**	0.46-0.66	0.69**	0.64-0.74
Four vs. Zero	0.46**	0.37-0.56	0.61**	0.57-0.66
Diabetes ACSC/All ACSC in 2006	4.79**	4.04-5.67	2.50**	2.39-2.62
Demographics				
Age (Reference: <60 years)				
60-64 years	0.83**	0.70-0.99	0.98	0.91-1.04
65-69 years	0.87	0.67-1.13	0.95	0.87-1.04
70-75 years	0.79	0.61-1.02	1.01	0.92-1.10
Female vs. Male	0.90**	0.82-0.99	1.12**	1.08-1.16
Race (Reference: White)				
Black	1.61**	1.43-1.80	1.10**	1.05-1.15
Other	0.98	0.80-1.21	0.91**	0.85-0.99
Median Zip code Income	1.00	1.00-1.00	1.00	1.00-1.00
Median Zip code Education (years)	0.97	0.91-1.03	0.99	0.97-1.01
Dual vs. Non Dual	1.36**	1.22-1.52	1.30**	1.25-1.36
Severity of Diabetes				
Type 1 vs. Type 2	1.80**	1.61-2.01	1.25**	1.20-1.31
Insulin vs. No Insulin	1.32**	1.04-1.68	1.12**	1.01-1.26
Self-Monitoring Blood Glucose	1.14**	1.02-1.26	1.03	0.99-1.07
Diabetes Duration in Years	1.10**	1.08-1.13	1.05**	1.05-1.06
Selected HCCs				
HCC15:Diabetes with Renal/Circulatory Manifestation	2.93**	2.09-4.10	1.05	0.96-1.15
HCC16:Diabetes with Neurologic/Other Manifestation	3.33**	2.39-4.64	1.13**	1.04-1.24
HCC32:Pancreatic Disease	1.40**	1.10-1.78	1.20**	1.08-1.33
HCC54: Schizophrenia	1.07	0.86-1.33	1.01	0.92-1.11
HCC55:Major Depressive, Bipolar, and Paranoid Disorders	0.99	0.83-1.17	1.14**	1.07-1.22

	Diabetes ACSC Hospitalizations in 2007		ACSC Hospitalizations in 2007	
	Odds Ratio	*95% CI of Odds Ratio*	*Odds Ratio*	*95% CI of Odds Ratio*
HCC70:Muscular Dystrophy	0.44	0.05-4.17	0.66	0.35-1.24
HCC71: Polyneuropathy	1.13**	1.01-1.29	1.08**	1.03-1.14
HCC77: Respirator Dependence	0.95	0.52-1.76	0.99	0.80-1.23
HCC80: Congestive Heart Failure	1.19**	1.05-1.34	1.75**	1.68-1.83
HCC81: Acute Myocardial Infarction	0.78	0.55-1.11	1.11	0.99-1.24
HCC82: Unstable Angina and Ischemic Heart Disease	1.15	0.95-1.38	1.17**	1.10-1.25
HCC95: Cerebral Hemorrhage	1.72**	1.06-2.80	1.05	0.86-1.29
HCC96: Ischemic or Unspecified Stroke	1.55**	1.32-1.82	1.25**	1.17-1.33
HCC100: Hemiplegia/Hemiparesis	0.68**	0.50-0.93	1.08	0.97-1.21
HCC104: Vascular Disease with Complications	1.18	0.95-1.47	1.19**	1.09-1.29
HCC108: Chronic Obstructive Pulmonary Disease	1.00	0.88-1.13	1.87**	1.79-1.94
HCC111: Aspiration and Specified Bacterial Pneumonias	0.77	0.50-1.17	1.08	0.94-1.23
HCC119: Proliferative Diabetic Retinopathy and Vitreous Hemorrhage	1.62**	1.36-1.95	1.31**	1.20-1.43
HCC131: Renal Failure	1.17**	1.02-1.34	1.33**	1.26-1.39

*** OR significant at P<0.05*

APPENDIX 6: MULTIVARIATE LOGISTIC REGRESSION PREDICTING THE LIKELIHOOD OF HOSPITALIZATION FOR DIABETES AND ALL AMBULATORY CARE SENSITIVE CONDITIONS (ACSC) IN 2007 BASED ON AMBULATORY DIABETES CARE PROCESSES WITHIN A MEASURE SET SUBGROUP IN 2006- ONE MEASURE

	Diabetes ACSC Hospitalizations in 2007		**ACSC Hospitalizations in 2007**	
	Odds Ratio	*95% CI of Odds Ratio*	*Odds Ratio*	*95% CI of Odds Ratio*
Diabetes Care Processes (Reference: LDLC)				
HbA1c	0.96	0.60-1.51	0.88	0.75-1.03
Eye Examination	1.19	0.78-1.83	1.03	0.89-1.20
Nephropathy Testing	1.34	0.86-2.07	1.09	0.94-1.27
Diabetes ACSC/All ACSC in 2006	6.14**	3.93-9.60	1.89**	1.62-2.21
Demographics				
Age (Reference: <60 years)				
60-64 years	0.92	0.58-1.48	1.33**	1.10-1.60
65-69 years	1.20	0.57-2.51	1.37**	1.04-1.81
70-75 years	0.81	0.38-1.70	1.34**	1.02-1.75
Female vs. Male	1.17	0.87-1.55	0.88	0.79-0.98
Race (Reference: White)				
Black	1.64**	1.22-2.21	1.16**	1.02-1.32
Other	1.24	0.75-2.05	0.96	0.77-1.19
Median Zip code Income	1.00	1.00-1.00	1.00	1.00-1.00
Median Zip code Education (years)	0.95	0.80-1.14	1.00	0.94-1.07
Dual vs. Non Dual	1.36**	1.01-1.85	1.10	0.97-1.23
Severity of Diabetes				
Type 1 vs. Type 2	2.18**	1.59-2.99	1.10	0.95-1.26
Insulin vs. No Insulin	0.83	0.37-1.88	1.30	0.92-1.82
Self-Monitoring Blood Glucose	1.23	0.91-1.65	1.05	0.94-1.17
Diabetes Duration in Years	1.13**	1.07-1.20	1.06**	1.03-1.08
Selected HCCs				
HCC15:Diabetes with Renal/Circulatory Manifestation	2.07**	1.01-4.29	1.39**	1.11-1.75
HCC16:Diabetes with Neurologic/Other Manifestation	2.08**	1.03-4.20	1.32**	1.06-1.64
HCC32:Pancreatic Disease	2.29**	1.38-3.80	1.20	0.91-1.60

	Diabetes ACSC Hospitalizations in 2007		ACSC Hospitalizations in 2007	
	Odds Ratio	*95% CI of Odds Ratio*	*Odds Ratio*	*95% CI of Odds Ratio*
HCC54: Schizophrenia	0.82	0.43-1.56	0.75	0.56-1.01
HCC55:Major Depressive, Bipolar, and Paranoid Disorders	0.90	0.55-1.45	1.16	0.96-1.41
HCC71: Polyneuropathy	1.71**	1.20-2.44	1.17**	1.01-1.38
HCC77: Respirator Dependence	3.35**	1.06-10.56	0.78	0.44-1.38
HCC80: Congestive Heart Failure	1.45**	1.01-2.07	1.69**	1.49-1.92
HCC81: Acute Myocardial Infarction	0.40	0.13-1.27	1.15	0.85-1.57
HCC82: Unstable Angina and Ischemic Heart Disease	0.79	0.42-1.50	1.5**7	1.29-1.91
HCC95: Cerebral Hemorrhage	2.63	0.87-8.00	1.53	0.93-2.52
HCC96: Ischemic or Unspecified Stroke	1.60**	1.01-2.53	1.34**	1.12-1.61
HCC100: Hemiplegia/Hemiparesis	0.72	0.32-1.66	0.97	0.71-1.31
HCC104: Vascular Disease with Complications	0.85	0.42-1.69	1.65**	1.33-2.05
HCC108: Chronic Obstructive Pulmonary Disease	0.87	0.61-1.24	1.17**	1.03-1.33
HCC111: Aspiration and Specified Bacterial Pneumonias	1.24	0.49-3.11	0.89	0.60-1.31
HCC119: Proliferative Diabetic Retinopathy and Vitreous Hemorrhage	2.63**	1.54-4.48	1.52**	1.13-2.04
HCC131: Renal Failure	0.93	0.63-1.39	1.49**	1.30-1.72

*** OR significant at P<0.05*

APPENDIX 7: MULTIVARIATE LOGISTIC REGRESSION PREDICTING THE LIKELIHOOD OF HOSPITALIZATION FOR DIABETES AND ALL AMBULATORY CARE SENSITIVE CONDITIONS (ACSC) IN 2007 BASED ON AMBULATORY DIABETES CARE PROCESSES WITHIN A MEASURE SET SUBGROUP IN 2006- TWO MEASURES

	Diabetes ACSC Hospitalizations in 2007		**ACSC Hospitalizations in 2007**	
	Odds Ratio	*95% CI of Odds Ratio*	*Odds Ratio*	*95% CI of Odds Ratio*
Diabetes Care Processes (Reference: : LDLC+HbA1c)				
LDLC+Eye Exam	0.64	0.37-1.12	0.98	0.85-1.14
LDLC + Nephropathy Testing	0.69	0.41-1.16	1.04	0.92-1.19
HbA1c+ Eye Exam	0.99	0.73-1.34	1.04	0.92-1.18
HbA1c+ Nephropathy Testing	1.24	0.93-1.66	1.14	1.00-1.28
Eye Exam + Nephropathy Testing	1.44**	1.03-2.08	1.35**	1.15-1.58
Diabetes ACSC/All ACSC in 2006	3.94	2.79-5.55	1.79	1.62-1.99
Demographics				
Age (Reference: <60 years)				
60-64 years	0.81	0.58-1.12	1.03	0.90-1.18
65-69 years	0.84	0.50-1.41	1.03	0.85-1.24
70-75 years	0.75	0.45-1.24	1.00	0.83-1.20
Female vs Male	0.85	0.69-1.03	0.93	0.86-1.00
Race (Reference: White)				
Black	1.78	1.42-2.23	1.13	1.03-1.24
Other	0.84	0.52-1.35	0.88	0.75-1.04
Median Zip code Income	1.00	1.00-1.00	1.00	1.00-1.00
Median Zip code Education (years)	0.89	0.79-1.00	0.96	0.92-1.00
Dual vs. Non Dual	1.26	1.01-1.57	1.13	1.04-1.22
Severity of Diabetes				
Type 1 vs. Type 2	1.41	1.13-1.76	1.26	1.16-1.38
Insulin vs. No Insulin	1.09	0.66-1.81	1.16	0.92-1.47
Self-Monitoring Blood Glucose	1.24	1.01-1.51	1.09	1.01-1.17
Diabetes Duration in Years	1.12	1.08-1.17	1.05	1.04-1.07
Selected HCCs				
HCC15:Diabetes with Renal/Circulatory Manifestation	9.11	2.10-39.50	1.18	0.97-1.43
HCC16:Diabetes with Neurologic/Other Manifestation	11.42	2.64-49.49	1.26	1.04-1.53
HCC32:Pancreatic Disease	1.29	0.83-2.02	1.38	1.14-1.68

	Diabetes ACSC Hospitalizations in 2007		ACSC Hospitalizations in 2007	
	Odds Ratio	*95% CI of Odds Ratio*	*Odds Ratio*	*95% CI of Odds Ratio*
HCC54: Schizophrenia	1.07	0.67-1.71	0.86	0.71-1.05
HCC55:Major Depressive, Bipolar, and Paranoid Disorders	1.35	0.99-1.84	0.98	0.86-1.12
HCC71: Polyneuropathy	1.19	0.93-1.51	1.05	0.95-1.17
HCC77: Respirator Dependence	1.36	0.56-3.30	0.79	0.51-1.22
HCC80: Congestive Heart Failure	1.22	0.96-1.54	1.48	1.36-1.62
HCC81: Acute Myocardial Infarction	0.85	0.46-1.58	1.38	1.12-1.70
HCC82: Unstable Angina and Ischemic Heart Disease	1.18	0.84-1.66	1.74	1.53-1.97
HCC95: Cerebral Hemorrhage	1.44	0.55-3.74	1.20	0.80-1.80
HCC96: Ischemic or Unspecified Stroke	1.45	1.06-1.98	1.46	1.29-1.65
HCC100: Hemiplegia/Hemiparesis	0.60	0.34-1.05	0.84	0.68-1.05
HCC104: Vascular Disease with Complications	1.16	0.77-1.76	1.75	1.51-2.04
HCC108: Chronic Obstructive Pulmonary Disease	0.86	0.67-1.10	1.25	1.14-1.36
HCC111: Aspiration and Specified Bacterial Pneumonias	0.28	0.10-0.81	0.79	0.58-1.08
HCC119: Proliferative Diabetic Retinopathy and Vitreous Hemorrhage	2.48	1.71-3.59	1.31	1.06-1.61
HCC131: Renal Failure	1.35	1.05-1.73	1.58	1.45-1.73

*** OR significant at P<0.05*

APPENDIX 8: MULTIVARIATE LOGISTIC REGRESSION PREDICTING THE LIKELIHOOD OF HOSPITALIZATION FOR DIABETES AND ALL AMBULATORY CARE SENSITIVE CONDITIONS (ACSC) IN 2007 BASED ON AMBULATORY DIABETES CARE PROCESSES WITHIN A MEASURE SET SUBGROUP IN 2006- THREE MEASURES

	Diabetes ACSC Hospitalizations in 2007		ACSC Hospitalizations in 2007	
	Odds Ratio	***95% CI of Odds Ratio***	***Odds Ratio***	***95% CI of Odds Ratio***
Diabetes Care Processes (Reference: : LDLC+HbA1c+ Eye Exam)				
LDLC+HBA1C+ Nephropathy Testing	0.72	0.39-1.35	0.94	0.79-1.11
LDLC+ Eye Exam+ Nephropathy Testing	1.08	0.88-1.31	1.02	0.95-1.09
HbA1c+ Eye Exam + Nephropathy Testing	1.24	0.89-1.71	1.08	0.95-1.23
Diabetes ACSC/All ACSC in 2006	5.05	3.76-6.80	1.75	1.59-1.92
Demographics				
Age (Reference: <60 years)				
60-64 years	0.74	0.55-1.01	1.00	0.88-1.13
65-69 years	0.73	0.47-1.15	1.11	0.94-1.30
70-75 years	0.73	0.47-1.13	1.04	0.88-1.22
Female vs Male	0.92	0.78-1.09	0.93	0.88-0.99
Race (Reference: White)				
Black	1.47	1.20-1.80	1.05	0.96-1.14
Other	1.06	0.75-1.51	0.94	0.83-1.07
Median Zip code Income	1.00	1.00-1.00	1.00	1.00-1.00
Median Zip code Education (years)	0.99	0.89-1.10	0.97	0.94-1.01
Dual vs. Non Dual	1.38	1.14-1.67	1.12	1.04-1.20
Severity of Diabetes				
Type 1 vs. Type 2	1.89	1.58-2.26	1.28	1.20-1.38
Insulin vs. No Insulin	1.42	0.95-2.12	1.06	0.87-1.29
Self-Monitoring Blood Glucose	1.04	0.87-1.23	1.10	1.03-1.17
Diabetes Duration in Years	1.09	1.05-1.13	1.04	1.03-1.06
Selected HCCs				
HCC15:Diabetes with Renal/Circulatory Manifestation	8.99	1.18-68.61	1.04	0.81-1.33
HCC16:Diabetes with Neurologic/Other Manifestation	9.86	1.30-75.03	1.08	0.84-1.38
HCC32:Pancreatic Disease	1.21	0.79-1.86	0.99	0.81-1.20
HCC54: Schizophrenia	1.12	0.78-1.60	0.90	0.76-1.08
HCC55:Major Depressive, Bipolar, and Paranoid Disorders	0.81	0.59-1.10	0.98	0.87-1.10

HCC71: Polyneuropathy	1.04	0.84-1.29	1.12	1.03-1.22
HCC77: Respirator Dependence	0.19	0.03-1.34	0.73	0.43-1.25
HCC80: Congestive Heart Failure	1.17	0.96-1.43	1.49	1.38-1.60
HCC81: Acute Myocardial Infarction	0.87	0.47-1.61	1.57	1.30-1.90
HCC82: Unstable Angina and Ischemic Heart Disease	1.23	0.90-1.67	1.65	1.47-1.85
HCC95: Cerebral Hemorrhage	0.78	0.27-2.31	0.99	0.70-1.41
HCC96: Ischemic or Unspecified Stroke	1.60	1.21-2.10	1.43	1.29-1.60
HCC100: Hemiplegia/Hemiparesis	0.65	0.38-1.12	0.90	0.74-1.11
HCC104: Vascular Disease with Complications	1.51	1.07-2.13	1.55	1.35-1.78
HCC108: Chronic Obstructive Pulmonary Disease	1.13	0.92-1.39	1.15	1.07-1.24
HCC111: Aspiration and Specified Bacterial Pneumonias	0.94	0.46-1.94	0.98	0.74-1.31
HCC119: Proliferative Diabetic Retinopathy and Vitreous Hemorrhage	1.10	0.79-1.53	1.32	1.16-1.50
HCC131: Renal Failure	1.27	1.00-1.62	1.42	1.30-1.55

*** OR significant at P<0.05*

APPENDIX 9: RESULTS OF EXPLORATORY FACTOR ANALYSIS WITH HALF-SAMPLE OF MEDICARE DIABETICS IN 2006

1. With Four Diabetes Care Process Measures: Hba1c testing, LDLC testing, Eye exams and testing for Nephropathy

```
Factor analysis/correlation                    Number of obs    =   192000
    Method: maximum likelihood                 Retained factors =        1
    Rotation: (unrotated)                      Number of params =        4
                                               Schwarz's BIC    =  322.874
    Log likelihood = -137.1064                 (Akaike's) AIC   =  282.213
```

Factor	Eigenvalue	Difference	Proportion	Cumulative
Factor1	0.91825	.	1.0000	1.0000

```
    LR test: independent vs. saturated:  chi2(6)  = 4.7e+04 Prob>chi2 = 0.0000
    LR test:    1 factor vs. saturated:  chi2(2)  =  274.21 Prob>chi2 = 0.0000
```

Factor loadings (pattern matrix) and unique variances

Variable	Factor1	Uniqueness
hba1c	0.6400	0.5904
ldlc	0.6278	0.6059
eye	0.1799	0.9676
nephro	0.2868	0.9178

2. With Eight Diabetes and Ambulatory Care Process Measures: Hba1c testing, LDLC testing, Eye exams, testing for Nephropathy, Evaluation & Management visit for Diabetes, Diabetes education, Cancer screening (breast or prostate) and Influenza Vaccination

```
Factor analysis/correlation                      Number of obs    =   192000
    Method: maximum likelihood                   Retained factors =        4
    Rotation: (unrotated)                        Number of params =       26
                                                 Schwarz's BIC    =  344.346
    Log likelihood = -14.02474                   (Akaike's) AIC   =  80.0495
```

Factor	Eigenvalue	Difference	Proportion	Cumulative
Factor1	1.36149	0.80274	0.5986	0.5986
Factor2	0.55875	0.26752	0.2457	0.8443
Factor3	0.29123	0.22834	0.1280	0.9723
Factor4	0.06289	.	0.0277	1.0000

```
    LR test: independent vs. saturated:  chi2(28) = 1.0e+05 Prob>chi2 = 0.0000
    LR test:   4 factors vs. saturated:  chi2(2)  =   28.05 Prob>chi2 = 0.0000
```

Factor loadings (pattern matrix) and unique variances

Variable	Factor1	Factor2	Factor3	Factor4	Uniqueness
hba1c	0.9573	-0.0466	-0.0123	-0.0061	0.0812
ldlc	0.4350	0.3132	-0.1621	0.0634	0.6824
eye	0.1273	0.2957	0.1757	-0.1351	0.8472
nephro	0.2035	0.2452	-0.0132	0.1023	0.8878
cancer	0.1809	0.4575	-0.1832	0.0077	0.7244
diab_edu	0.0851	0.0958	0.0768	0.0707	0.9727
flu	0.1351	0.2660	0.0587	-0.1407	0.8877
emvisit_diab	0.3742	0.1473	0.4369	0.0725	0.6421

APPENDIX 10: MULTIVARIATE LOGISTIC REGRESSION PREDICTING THE LIKELIHOOD OF HOSPITALIZATION FOR DIABETES AND ALL AMBULATORY CARE SENSITIVE CONDITIONS (ACSC) IN 2007 BASED ON HBA1C TESTING IN 2006

	Diabetes ACSC Hospitalizations in 2007		ACSC Hospitalizations in 2007	
	Odds Ratio	***95% CI of Odds Ratio***	***Odds Ratio***	***95% CI of Odds Ratio***
Diabetes Care Processes				
HbA1c	0.77	0.68-0.87	0.8	0.76-0.83
Diabetes ACSC/All ACSC in 2006	4.90	4.19-5.75	2.54	2.43-2.65
Demographics				
Age (Reference: <60 years)				
60-64 years	0.82	0.70-0.98	0.97	0.91-1.03
65-69 years	0.86	0.66-1.12	0.95	0.86-1.04
70-75 years	0.77	0.60-1.00	0.99	0.91-1.09
Female vs Male	0.88	0.80-0.97	1.10	1.07-1.14
Race (Reference: White)				
Black	1.63	1.45-1.82	1.11	1.06-1.16
Other	0.98	0.80-1.21	0.91	0.85-0.98
Median Zip code Income	1.00	1.00-1.00	1.00	1.00-1.00
Median Zip code Education (years)	0.97	0.91-1.03	0.99	0.97-1.02
Dual vs. Non Dual	1.36	1.22-1.52	1.30	1.25-1.35
Severity of Diabetes				
Type 1 vs. Type 2	1.78	1.60-1.98	1.25	1.20-1.30
Insulin vs. No Insulin	1.31	1.04-1.65	1.12	1.01-1.25
Self-Monitoring Blood Glucose	1.11	1.00-1.23	1.03	0.99-1.06
Diabetes Duration in Years	1.11	1.08-1.13	1.05	1.05-1.06
Selected HCCs				
HCC15:Diabetes with Renal/Circulatory Manifestation	2.71	1.93-3.82	1.05	0.96-1.15
HCC16:Diabetes with Neurologic/Other Manifestation	3.04	2.17-4.26	1.12	1.03-1.23
HCC32:Pancreatic Disease	1.39	1.09-1.77	1.19	1.08-1.31
HCC54: Schizophrenia	1.05	0.84-1.30	1.00	0.91-1.09
HCC55:Major Depressive, Bipolar, and Paranoid Disorders	0.97	0.82-1.16	1.13	1.06-1.20
HCC71: Polyneuropathy	1.12	0.99-1.27	1.07	1.02-1.13

	Diabetes ACSC Hospitalizations in 2007		ACSC Hospitalizations in 2007	
	Odds Ratio	***95% CI of Odds Ratio***	***Odds Ratio***	***95% CI of Odds Ratio***
HCC77: Respirator Dependence	0.97	0.53-1.76	1.00	0.82-1.22
HCC80: Congestive Heart Failure	1.19	1.06-1.34	1.76	1.69-1.83
HCC81: Acute Myocardial Infarction	0.79	0.57-1.10	1.11	0.99-1.23
HCC82: Unstable Angina and Ischemic Heart Disease	1.14	0.95-1.37	1.16	1.09-1.24
HCC95: Cerebral Hemorrhage	1.70	1.07-2.72	1.05	0.87-1.26
HCC96: Ischemic or Unspecified Stroke	1.55	1.32-1.81	1.24	1.17-1.32
HCC100: Hemiplegia/Hemiparesis	0.69	0.51-0.93	1.09	0.98-1.21
HCC104: Vascular Disease with Complications	1.19	0.97-1.46	1.19	1.10-1.28
HCC108: Chronic Obstructive Pulmonary Disease	1.00	0.88-1.13	1.86	1.79-1.93
HCC111: Aspiration and Specified Bacterial Pneumonias	0.78	0.52-1.17	1.08	0.95-1.22
HCC119: Proliferative Diabetic Retinopathy and Vitreous Hemorrhage	1.51	1.27-1.79	1.25	1.15-1.36
HCC131: Renal Failure	1.24	1.10-1.41	1.39	1.33-1.46

APPENDIX 11: MULTIVARIATE LOGISTIC REGRESSION PREDICTING THE LIKELIHOOD OF HOSPITALIZATION FOR DIABETES AND ALL AMBULATORY CARE SENSITIVE CONDITIONS (ACSC) IN 2007 BASED ON LDLC TESTING IN 2006

	Diabetes ACSC Hospitalizations in 2007		ACSC Hospitalizations in 2007	
	Odds Ratio	***95% CI of Odds Ratio***	***Odds Ratio***	***95% CI of Odds Ratio***
Diabetes Care Processes				
LDLC	0.67	0.61-0.75	0.73	0.70-0.76
Diabetes ACSC/All ACSC in 2006	4.77	4.07-5.60	2.50	2.39-2.61
Demographics				
Age (Reference: <60 years)				
60-64 years	0.83	0.70-0.98	0.97	0.91-1.04
65-69 years	0.87	0.67-1.12	0.95	0.86-1.04
70-75 years	0.78	0.61-1.01	1.00	0.91-1.09
Female vs Male	0.88	0.80-0.97	1.11	1.07-1.14
Race (Reference: White)				
Black	1.62	1.44-1.81	1.10	1.05-1.15
Other	0.99	0.80-1.21	0.91	0.85-0.98
Median Zip code Income	0.96	0.90-1.02	1.00	1.00-1.00
Median Zip code Education (years)	1.00	1.00-1.00	0.99	0.97-1.01
Dual vs. Non Dual	1.35	1.21-1.50	1.30	1.25-1.35
Severity of Diabetes				
Type 1 vs. Type 2	1.77	1.59-1.97	1.24	1.19-1.29
Insulin vs. No Insulin	1.32	1.05-1.66	1.13	1.01-1.26
Self-Monitoring Blood Glucose	1.11	1.01-1.23	1.02	0.98-1.06
Diabetes Duration in Years	1.10	1.08-1.13	1.05	1.04-1.06
Selected HCCs				
HCC15:Diabetes with Renal/Circulatory Manifestation	2.61	1.87-3.64	1.00	0.92-1.09
HCC16:Diabetes with Neurologic/Other Manifestation	2.90	2.09-4.03	1.06	0.97-1.15
HCC32:Pancreatic Disease	1.39	1.09-1.77	1.20	1.09-1.32
HCC54: Schizophrenia	1.05	0.85-1.31	1.00	0.92-1.09
HCC55:Major Depressive, Bipolar, and Paranoid Disorders	1.05	0.85-1.31	1.13	1.06-1.20
HCC71: Polyneuropathy	1.13	0.99-1.27	1.08	1.03-1.13
HCC77: Respirator Dependence	0.96	0.53-1.73	0.99	0.81-1.20
HCC80: Congestive Heart Failure	1.19	1.06-1.34	1.76	1.69-1.83

	Diabetes ACSC Hospitalizations in 2007		ACSC Hospitalizations in 2007	
	Odds Ratio	***95% CI of Odds Ratio***	***Odds Ratio***	***95% CI of Odds Ratio***
HCC81: Acute Myocardial Infarction	0.81	0.58-1.13	1.13	1.01-1.26
HCC82: Unstable Angina and Ischemic Heart Disease	1.16	0.96-1.39	1.19	1.11-1.27
HCC95: Cerebral Hemorrhage	1.71	1.07-2.72	1.06	0.88-1.28
HCC96: Ischemic or Unspecified Stroke	1.55	1.32-1.81	1.24	1.17-1.32
HCC100: Hemiplegia/Hemiparesis	0.68	0.51-0.92	1.08	0.97-1.20
HCC104: Vascular Disease with Complications	1.19	0.97-1.46	1.19	1.10-1.29
HCC108: Chronic Obstructive Pulmonary Disease	1.00	0.89-1.13	1.87	1.80-1.94
HCC111: Aspiration and Specified Bacterial Pneumonias	0.76	0.50-1.14	1.06	0.94-1.20
HCC119: Proliferative Diabetic Retinopathy and Vitreous Hemorrhage	1.50	1.27-1.78	1.25	1.15-1.36
HCC131: Renal Failure	1.24	1.09-1.41	1.39	1.33-1.46

APPENDIX 12: MULTIVARIATE LOGISTIC REGRESSION PREDICTING THE LIKELIHOOD OF HOSPITALIZATION FOR DIABETES AND ALL AMBULATORY CARE SENSITIVE CONDITIONS (ACSC) IN 2007 BASED ON EYE EXAM IN 2006

	Diabetes ACSC Hospitalizations in 2007		ACSC Hospitalizations in 2007	
	Odds Ratio	***95% CI of Odds Ratio***	***Odds Ratio***	***95% CI of Odds Ratio***
Diabetes Care Processes				
Dilated Eye Exam	0.79	0.71-0.88	0.87	0.84-0.90
Diabetes ACSC/All ACSC in 2006	4.90	4.18-5.74	2.56	2.45-2.67
Demographics				
Age (Reference: <60 years)				
60-64 years	0.83	0.70-0.98	0.97	0.91-1.04
65-69 years	0.86	0.66-1.12	0.95	0.86-1.04
70-75 years	0.78	0.61-1.01	1.00	0.92-1.10
Female vs Male	0.89	0.80-0.98	1.11	1.07-1.15
Race (Reference: White)				
Black	1.64	1.46-1.84	1.12	1.07-1.17
Other	0.99	0.81-1.22	0.92	0.85-0.99
Median Zip code Income	1.00	1.00-1.00	1.00	1.00-1.00
Median Zip code Education (years)	0.97	0.91-1.03	0.99	0.97-1.01
Dual vs. Non Dual	1.35	1.21-1.51	1.30	1.25-1.35
Severity of Diabetes				
Type 1 vs. Type 2	1.78	1.60-1.98	1.25	1.20-1.30
Insulin vs. No Insulin	1.30	1.03-1.64	1.12	1.01-1.25
Self-Monitoring Blood Glucose	1.09	0.98-1.21	1.01	0.97-1.04
Diabetes Duration in Years	1.10	1.08-1.13	1.05	1.04-1.06
Selected HCCs				
HCC15:Diabetes with Renal/Circulatory Manifestation	2.36	1.69-3.29	0.93	0.85-1.01
HCC16:Diabetes with Neurologic/Other Manifestation	2.65	1.91-3.68	0.99	0.91-1.08
HCC32:Pancreatic Disease	1.39	1.09-1.77	1.19	1.08-1.32
HCC54: Schizophrenia	1.05	0.84-1.30	1.00	0.92-1.10
HCC55:Major Depressive, Bipolar, and Paranoid Disorders	1.05	0.84-1.30	1.13	1.07-1.21
HCC71: Polyneuropathy	1.12	0.99-1.27	1.07	1.02-1.13
HCC77: Respirator Dependence	0.97	0.54-1.77	1.00	0.82-1.22
HCC80: Congestive Heart Failure	1.19	1.06-1.34	1.76	1.69-1.83

	Diabetes ACSC Hospitalizations in 2007		ACSC Hospitalizations in 2007	
	Odds Ratio	***95% CI of Odds Ratio***	***Odds Ratio***	***95% CI of Odds Ratio***
HCC81: Acute Myocardial Infarction	0.79	0.56-1.10	1.11	0.99-1.23
HCC82: Unstable Angina and Ischemic Heart Disease	1.14	0.95-1.37	1.16	1.09-1.24
HCC95: Cerebral Hemorrhage	1.70	1.06-2.72	1.05	0.87-1.27
HCC96: Ischemic or Unspecified Stroke	1.55	1.32-1.81	1.24	1.17-1.32
HCC100: Hemiplegia/Hemiparesis	0.68	0.51-0.92	1.09	0.98-1.21
HCC104: Vascular Disease with Complications	1.19	0.97-1.46	1.19	1.10-1.29
HCC108: Chronic Obstructive Pulmonary Disease	1.00	0.89-1.13	1.86	1.79-1.94
HCC111: Aspiration and Specified Bacterial Pneumonias	0.78	0.52-1.18	1.08	0.96-1.23
HCC119: Proliferative Diabetic Retinopathy and Vitreous Hemorrhage	1.66	1.39-1.98	1.32	1.22-1.44
HCC131: Renal Failure	1.24	1.09-1.40	1.38	1.32-1.45

APPENDIX 12: MULTIVARIATE LOGISTIC REGRESSION PREDICTING THE LIKELIHOOD OF HOSPITALIZATION FOR DIABETES AND ALL AMBULATORY CARE SENSITIVE CONDITIONS (ACSC) IN 2007 BASED ON NEPHROPATHY TESTING IN 2006

	Diabetes ACSC Hospitalizations in 2007		ACSC Hospitalizations in 2007	
	Odds Ratio	***95% CI of Odds Ratio***	***Odds Ratio***	***95% CI of Odds Ratio***
Diabetes Care Processes				
Nephropathy Testing	0.85	0.77-0.95	0.94	0.91-0.97
Diabetes ACSC/All ACSC in 2006	4.95	4.22-5.80	2.57	2.46-2.68
Demographics				
Age (Reference: <60 years)				
60-64 years	0.82	0.69-0.97	0.96	0.90-1.03
65-69 years	0.85	0.66-1.10	0.94	0.86-1.03
70-75 years	0.77	0.60-0.99	0.99	0.91-1.08
Female vs Male	0.88	0.80-0.97	1.10	1.06-1.14
Race (Reference: White)			|	
Black	1.64	1.47-1.84	1.12	1.07-1.17
Other	0.99	0.81-1.22	0.92	0.85-0.99
Median Zip code Income	1.00	1.00-1.00	1.00	1.00-1.00
Median Zip code Education (years)	0.97	0.91-1.02	0.99	0.97-1.01
Dual vs. Non Dual	1.36	1.22-1.52	1.30	1.25-1.36
Severity of Diabetes				
Type 1 vs. Type 2	1.77	1.59-1.97	1.24	1.19-1.29
Insulin vs. No Insulin	1.30	1.03-1.64	1.12	1.00-1.25
Self-Monitoring Blood Glucose	1.09	0.98-1.20	1.00	0.97-1.04
Diabetes Duration in Years	1.10	1.08-1.13	1.05	1.04-1.06
Selected HCCs				
HCC15:Diabetes with Renal/Circulatory Manifestation	2.32	1.66-3.24	0.91	0.84-1.00
HCC16:Diabetes with Neurologic/Other Manifestation	2.68	1.93-3.72	0.99	0.91-1.07
HCC32:Pancreatic Disease	1.17	0.89-1.52	1.20	1.08-1.32
HCC54: Schizophrenia	1.05	0.85-1.30	1.00	0.92-1.09
HCC55:Major Depressive, Bipolar, and Paranoid Disorders	0.98	0.82-1.16	1.13	1.07-1.21
HCC71: Polyneuropathy	1.12	0.99-1.27	1.07	1.02-1.13
HCC77: Respirator Dependence	0.97	0.54-1.77	1.01	0.83-1.23
HCC80: Congestive Heart Failure	1.19	1.06-1.34	1.76	1.69-1.83

	Diabetes ACSC Hospitalizations in 2007		ACSC Hospitalizations in 2007	
	Odds Ratio	***95% CI of Odds Ratio***	***Odds Ratio***	***95% CI of Odds Ratio***
HCC81: Acute Myocardial Infarction	0.79	0.57-1.11	1.11	1.00-1.24
HCC82: Unstable Angina and Ischemic Heart Disease	1.14	0.95-1.37	1.17	1.09-1.24
HCC95: Cerebral Hemorrhage	1.72	1.07-2.74	1.05	0.87-1.27
HCC96: Ischemic or Unspecified Stroke	1.55	1.32-1.81	1.24	1.17-1.32
HCC100: Hemiplegia/Hemiparesis	0.69	0.51-0.93	1.09	0.98-1.21
HCC104: Vascular Disease with Complications	1.19	0.97-1.46	1.19	1.10-1.29
HCC108: Chronic Obstructive Pulmonary Disease	1.00	0.89-1.13	1.87	1.80-1.94
HCC111: Aspiration and Specified Bacterial Pneumonias	0.78	0.52-1.17	1.08	0.95-1.22
HCC119: Proliferative Diabetic Retinopathy and Vitreous Hemorrhage	1.50	1.27-1.78	1.25	1.15-1.36
HCC131: Renal Failure	1.16	1.02-1.32	1.35	1.29-1.42

APPENDIX 14: MULTIVARIATE LOGISTIC REGRESSION PREDICTING THE LIKELIHOOD OF HOSPITALIZATION FOR DIABETES AND ALL AMBULATORY CARE SENSITIVE CONDITIONS (ACSC) IN 2007 BASED ON HBA1C TESTING IN 2006 WITH PROPENSITY SCORE INVERSE PROBABILITY TREATMENT WEIGHTING

	Diabetes ACSC Hospitalizations in 2007		**ACSC Hospitalizations in 2007**	
	Odds Ratio	*95% CI of Odds Ratio*	*Odds Ratio*	*95% CI of Odds Ratio*
Diabetes Care Processes				
HbA1c	0.75	0.63-0.90	0.86	0.80-0.91
Diabetes ACSC/All ACSC in 2006	5.84	4.25-8.03	2.51	2.27-2.77
Demographics				
Age (Reference: <60 years)				
60-64 years	0.82	0.60-1.12	0.96	0.83-1.11
65-69 years	1.04	0.64-1.69	0.97	0.81-1.18
70-75 years	0.83	0.51-1.36	0.96	0.80-1.16
Female vs. Male	0.98	0.82-1.18	1.10	1.03-1.18
Race (Reference: White)				
Black	1.46	1.15-1.85	1.20	1.08-1.33
Other	0.80	0.53-1.20	0.97	0.84-1.13
Median Zip code Income	1.00	1.00-1.00	1.00	1.00-1.00
Median Zip code Education (years)	1.04	0.88-1.22	0.97	0.92-1.02
Dual vs. Non Dual	1.54	1.17-2.04	1.23	1.12-1.34
Severity of Diabetes				
Type 1 vs. Type 2	1.83	1.42-2.37	1.25	1.13-1.38
Insulin vs. No Insulin	1.11	0.62-1.97	0.99	0.78-1.26
Self-Monitoring Blood Glucose	1.01	0.82-1.24	1.06	0.99-1.15
Diabetes Duration in Years	1.08	1.03-1.14	1.05	1.03-1.07
Selected HCCs				
HCC15:Diabetes with Renal/Circulatory Manifestation	3.07	1.67-5.65	0.88	0.74-1.05
HCC16:Diabetes with Neurologic/Other Manifestation	3.33	1.84-6.01	1.15	0.95-1.38
HCC32:Pancreatic Disease	1.10	0.73-1.66	1.00	0.83-1.19
HCC54: Schizophrenia	1.04	0.66-1.63	0.96	0.81-1.13
HCC55:Major Depressive, Bipolar, and Paranoid Disorders	0.91	0.66-1.27	1.05	0.94-1.19
HCC71: Polyneuropathy	1.27	0.98-1.65	1.06	0.94-1.20
HCC77: Respirator Dependence	0.83	0.36-1.93	1.03	0.73-1.46
HCC80: Congestive Heart Failure	1.26	0.93-1.72	1.87	1.70-2.06

	Diabetes ACSC Hospitalizations in 2007		ACSC Hospitalizations in 2007	
	Odds Ratio	*95% CI of Odds Ratio*	*Odds Ratio*	*95% CI of Odds Ratio*
HCC81: Acute Myocardial Infarction	1.04	0.55-1.95	1.13	0.92-1.38
HCC82: Unstable Angina and Ischemic Heart Disease	1.30	0.92-1.84	1.31	1.14-1.50
HCC95: Cerebral Hemorrhage	1.18	0.54-2.57	0.95	0.70-1.28
HCC96: Ischemic or Unspecified Stroke	1.18	0.90-1.54	1.16	1.00-1.34
HCC100: Hemiplegia/Hemiparesis	0.70	0.41-1.19	1.05	0.79-1.41
HCC104: Vascular Disease with Complications	1.19	0.79-1.81	1.17	0.98-1.41
HCC108: Chronic Obstructive Pulmonary Disease	0.23	0.02-2.50	1.93	1.78-2.11
HCC111: Aspiration and Specified Bacterial Pneumonias	0.84	0.47-1.47	0.93	0.75-1.14
HCC119: Proliferative Diabetic Retinopathy and Vitreous Hemorrhage	1.67	1.21-2.31	1.16	0.97-1.37
HCC131: Renal Failure	1.30	0.98-1.73	1.50	1.33-1.68

APPENDIX 15: MULTIVARIATE LOGISTIC REGRESSION PREDICTING THE LIKELIHOOD OF HOSPITALIZATION FOR DIABETES AND ALL AMBULATORY CARE SENSITIVE CONDITIONS (ACSC) IN 2007 BASED ON LDLC TESTING IN 2006 WITH PROPENSITY SCORE INVERSE PROBABILITY TREATMENT WEIGHTING

	Diabetes ACSC Hospitalizations in 2007		**ACSC Hospitalizations in 2007**	
	Odds Ratio	*95% CI of Odds Ratio*	*Odds Ratio*	*95% CI of Odds Ratio*
Diabetes Care Processes				
LCLC	0.72	0.63-0.82	0.77	0.74-0.81
Diabetes ACSC/All ACSC in 2006	4.77	3.72-6.11	2.52	2.35-2.70
Demographics				
Age (Reference: <60 years)				
60-64 years	0.88	0.69-1.11	1.02	0.93-1.13
65-69 years	1.10	0.75-1.61	1.04	0.91-1.20
70-75 years	1.01	0.69-1.47	1.07	0.93-1.23
Female vs Male	0.86	0.74-1.01	1.09	1.03-1.15
Race (Reference: White)				
Black	1.51	1.28-1.79	1.07	1.01-1.15
Other	1.16	0.87-1.57	0.94	0.84-1.05
Median Zip code Income	1.00	1.00-1.00	1.00	1.00-1.00
Median Zip code Education (years)	0.93	0.84-1.03	0.97	0.94-1.00
Dual vs. Non Dual	1.43	1.19-1.70	1.34	1.26-1.43
Severity of Diabetes				
Type 1 vs. Type 2	1.85	1.55-2.20	1.24	1.16-1.33
Insulin vs. No Insulin	1.10	0.81-1.51	1.17	0.91-1.50
Self-Monitoring Blood Glucose	1.05	0.90-1.23	1.00	0.95-1.06
Diabetes Duration in Years	1.10	1.07-1.14	1.04	1.03-1.05
Selected HCCs				
HCC15:Diabetes with Renal/Circulatory Manifestation	3.39	2.30-4.98	1.00	0.89-1.12
HCC16:Diabetes with Neurologic/Other Manifestation	3.66	2.52-5.31	1.13	1.01-1.26
HCC32:Pancreatic Disease	1.32	0.99-1.77	1.15	1.00-1.32
HCC54: Schizophrenia	0.96	0.74-1.24	0.99	0.83-1.18
HCC55:Major Depressive, Bipolar, and Paranoid Disorders	1.01	0.78-1.30	1.08	0.98-1.18
HCC71: Polyneuropathy	1.06	0.86-1.29	0.99	0.91-1.08

	Diabetes ACSC Hospitalizations in 2007		ACSC Hospitalizations in 2007	
	Odds Ratio	*95% CI of Odds Ratio*	*Odds Ratio*	*95% CI of Odds Ratio*
HCC77: Respirator Dependence	0.97	0.47-1.99	1.01	0.77-1.34
HCC80: Congestive Heart Failure	1.13	0.90-1.43	1.80	1.68-1.93
HCC81: Acute Myocardial Infarction	0.70	0.46-1.05	1.05	0.87-1.27
HCC82: Unstable Angina and Ischemic Heart Disease	1.47	1.05-2.08	1.13	1.01-1.27
HCC95: Cerebral Hemorrhage	1.71	0.90-3.24	1.04	0.82-1.32
HCC96: Ischemic or Unspecified Stroke	1.76	1.34-2.33	1.27	1.14-1.41
HCC100: Hemiplegia/Hemiparesis	0.56	0.39-0.80	1.08	0.93-1.26
HCC104: Vascular Disease with Complications	0.98	0.72-1.33	1.15	1.02-1.29
HCC108: Chronic Obstructive Pulmonary Disease	1.01	0.82-1.23	1.90	1.78-2.02
HCC111: Aspiration and Specified Bacterial Pneumonias	0.70	0.40-1.21	0.93	0.76-1.13
HCC119: Proliferative Diabetic Retinopathy and Vitreous Hemorrhage	1.52	1.18-1.96	1.38	1.19-1.60
HCC131: Renal Failure	1.20	0.96-1.50	1.30	1.20-1.40

APPENDIX 16: MULTIVARIATE LOGISTIC REGRESSION PREDICTING THE LIKELIHOOD OF HOSPITALIZATION FOR DIABETES AND ALL AMBULATORY CARE SENSITIVE CONDITIONS (ACSC) IN 2007 BASED ON EYE EXAM IN 2006 WITH PROPENSITY SCORE INVERSE PROBABILITY TREATMENT WEIGHTING

	Diabetes ACSC Hospitalizations in 2007		**ACSC Hospitalizations in 2007**	
	Odds Ratio	*95% CI of Odds Ratio*	*Odds Ratio*	*95% CI of Odds Ratio*
Diabetes Care Processes				
Dilated Eye Exam	0.91	0.7-1.09	0.9	0.84-0.97
Diabetes ACSC/All ACSC in 2006	4.59	3.64-5.79	2.43	2.18-2.70
Demographics				
Age (Reference: <60 years)				
60-64 years	0.77	0.54-1.09	0.87	0.76-1.01
65-69 years	0.82	0.53-1.26	0.91	0.77-1.09
70-75 years	0.68	0.44-1.04	0.88	0.74-1.05
Female vs Male	1.00	0.81-1.23	1.13	1.06-1.21
Race (Reference: White)				
Black	1.57	1.32-1.87	0.99	0.90-1.11
Other	1.62	0.63-4.20	0.95	0.78-1.15
Median Zip code Income	1.00	1.00-1.00	1.00	1.00-1.00
Median Zip code Education (years)	1.03	0.91-1.16	0.98	0.94-1.02
Dual vs. Non Dual	1.13	0.84-1.53	1.32	1.20-1.45
Severity of Diabetes				
Type 1 vs. Type 2	1.63	1.37-1.93	1.23	1.13-1.33
Insulin vs. No Insulin	0.82	0.47-1.45	1.16	0.65-2.07
Self-Monitoring Blood Glucose	1.20	0.96-1.50	0.95	0.88-1.04
Diabetes Duration in Years	1.11	1.07-1.14	1.05	1.03-1.06
Selected HCCs				
HCC15:Diabetes with Renal/Circulatory Manifestation	3.47	2.35-5.11	0.95	0.84-1.09
HCC16:Diabetes with Neurologic/Other Manifestation	3.32	2.26-4.86	0.95	0.84-1.07
HCC32:Pancreatic Disease	1.37	1.03-1.82	1.09	0.94-1.25
HCC54: Schizophrenia	1.01	0.73-1.39	1.00	0.85-1.18
HCC55:Major Depressive, Bipolar, and Paranoid Disorders	0.83	0.61-1.12	1.02	0.87-1.19
HCC71: Polyneuropathy	1.43	0.95-2.16	1.13	1.01-1.26
HCC77: Respirator Dependence	1.08	0.53-2.19	1.00	0.74-1.36

	Diabetes ACSC Hospitalizations in 2007		ACSC Hospitalizations in 2007	
	Odds Ratio	*95% CI of Odds Ratio*	*Odds Ratio*	*95% CI of Odds Ratio*
HCC80: Congestive Heart Failure	1.13	0.96-1.34	1.98	1.78-2.19
HCC81: Acute Myocardial Infarction	0.78	0.52-1.16	1.12	0.97-1.29
HCC82: Unstable Angina and Ischemic Heart Disease	1.20	0.95-1.51	1.26	1.10-1.45
HCC95: Cerebral Hemorrhage	1.52	0.74-3.15	1.03	0.79-1.35
HCC96: Ischemic or Unspecified Stroke	1.61	1.32-1.95	1.30	1.19-1.42
HCC100: Hemiplegia/Hemiparesis	0.77	0.52-1.15	1.08	0.94-1.25
HCC104: Vascular Disease with Complications	1.18	0.87-1.60	1.13	0.99-1.28
HCC108: Chronic Obstructive Pulmonary Disease	0.98	0.84-1.13	1.89	1.76-2.04
HCC111: Aspiration and Specified Bacterial Pneumonias	0.60	0.35-1.03	1.13	0.91-1.40
HCC119: Proliferative Diabetic Retinopathy and Vitreous Hemorrhage	1.13	0.76-1.67	0.80	0.58-1.12
HCC131: Renal Failure	1.22	1.02-1.45	1.41	1.30-1.53

APPENDIX 17: MULTIVARIATE LOGISTIC REGRESSION PREDICTING THE LIKELIHOOD OF HOSPITALIZATION FOR DIABETES AND ALL AMBULATORY CARE SENSITIVE CONDITIONS (ACSC) IN 2007 BASED ON NEPHROPATHY TESTING IN 2006 WITH PROPENSITY SCORE INVERSE PROBABILITY TREATMENT WEIGHTING

	Diabetes ACSC Hospitalizations in 2007		**ACSC Hospitalizations in 2007**	
	Odds Ratio	*95% CI of Odds Ratio*	*Odds Ratio*	*95% CI of Odds Ratio*
Diabetes Care Processes				
Nephropathy Testing	0.94	0.84-1.05	0.96	0.92-1.00
Diabetes ACSC/All ACSC in 2006	4.87	3.98-5.97	2.54	2.40-2.70
Demographics				
Age (Reference: <60 years)				
60-64 years	0.80	0.66-0.97	0.98	0.90-1.07
65-69 years	0.95	0.70-1.28	1.00	0.89-1.12
70-75 years	0.78	0.58-1.05	1.03	0.92-1.15
Female vs. Male	0.90	0.80-1.01	1.10	1.06-1.15
Race (Reference: White)				
Black	1.64	1.42-1.88	1.10	1.04-1.16
Other	1.02	0.80-1.31	0.92	0.85-1.01
Median Zip code Income	1.00	1.00-1.00	1.00	1.00-1.00
Median Zip code Education (years)	0.95	0.89-1.03	0.99	0.96-1.01
Dual vs. Non Dual	1.32	1.15-1.51	1.28	1.22-1.35
Severity of Diabetes				
Type 1 vs. Type 2	1.81	1.59-2.06	1.26	1.19-1.32
Insulin vs. No Insulin	1.20	0.91-1.58	1.05	0.91-1.21
Self-Monitoring Blood Glucose	1.11	0.98-1.26	1.02	0.97-1.06
Diabetes Duration in Years	1.11	1.08-1.14	1.05	1.04-1.06
Selected HCCs				
HCC15:Diabetes with Renal/Circulatory Manifestation	2.69	1.85-3.93	0.93	0.83-1.04
HCC16:Diabetes with Neurologic/Other Manifestation	3.31	2.28-4.79	1.00	0.90-1.12
HCC32:Pancreatic Disease	1.38	1.05-1.83	1.23	1.09-1.39
HCC54: Schizophrenia	1.00	0.77-1.31	1.00	0.90-1.11
HCC55:Major Depressive, Bipolar, and Paranoid Disorders	0.99	0.80-1.23	1.16	1.07-1.25
HCC71: Polyneuropathy	1.09	0.94-1.26	1.05	0.99-1.12
HCC77: Respirator Dependence	0.98	0.49-1.94	0.88	0.67-1.17

	Diabetes ACSC Hospitalizations in 2007		ACSC Hospitalizations in 2007	
	Odds Ratio	*95% CI of Odds Ratio*	*Odds Ratio*	*95% CI of Odds Ratio*
HCC80: Congestive Heart Failure	1.20	1.03-1.41	1.77	1.68-1.86
HCC81: Acute Myocardial Infarction	0.93	0.57-1.53	1.18	1.01-1.37
HCC82: Unstable Angina and Ischemic Heart Disease	1.05	0.84-1.32	1.12	1.03-1.21
HCC95: Cerebral Hemorrhage	1.45	0.80-2.65	1.10	0.86-1.41
HCC96: Ischemic or Unspecified Stroke	1.45	1.16-1.81	1.28	1.18-1.39
HCC100: Hemiplegia/Hemiparesis	0.79	0.48-1.28	1.10	0.94-1.28
HCC104: Vascular Disease with Complications	1.38	1.06-1.80	1.19	1.07-1.31
HCC108: Chronic Obstructive Pulmonary Disease	0.94	0.81-1.09	1.86	1.77-1.95
HCC111: Aspiration and Specified Bacterial Pneumonias	0.90	0.56-1.46	1.06	0.89-1.26
HCC119: Proliferative Diabetic Retinopathy and Vitreous Hemorrhage	1.52	1.23-1.88	1.25	1.12-1.39
HCC131: Renal Failure	1.30	1.09-1.56	1.33	1.25-1.43

APPENDIX 18: CODES TO IDENTIFY PQRS REPORTING FOR DIABETES CARE PROCESSES FROM MEDICARE CLAIMS

Measure/Variable	Codes
Diabetes Care Processes	
HbA1c Testing	CPT codes 3044F, 3045F, and 3046F,
LDLC Testing	CPT codes: 3048F, 3049F, and 3050F
Blood Pressure Measurement	CPT codes: 3074F, 3075F, 3077F, 3078F, 3079F, 3080F,
Dilated Eye Exams	CPT codes: 2022F, 2024F, 2026F, and 3072F
Testing for Nephropathy	CPT codes: 3060F, 3061F , 3062F and 3066F

APPENDIX 19: NATIONAL DRUG CODES TO IDENTIFY PHARMACOTHERAPY FOR DIABETICS FROM MEDICARE PART D CLAIMS

Pharmacotherapy	National Drug Codes
Insulin	Source: HEDIS 2011 NDC List. Table CDC-A/Table DCDC-A.xls. Available at: http://www.ncqa.org/HEDISQualityMeasurement/HEDISMeasures/HEDIS 2011/HEDIS2011NDCLicense/HEDIS2011FinalNDCLists.aspx
Oral Anti-Diabetic Agents	Source: HEDIS 2011 NDC List. Table CDC-A/Table DCDC-A.xls. Available at: http://www.ncqa.org/HEDISQualityMeasurement/HEDISMeasures/HEDIS 2011/HEDIS2011NDCLicense/HEDIS2011FinalNDCLists.aspx
ACE Inhibitors/ARBs	Source: HEDIS 2011 NDC List. Table CDC-L/ Table DCDC-P.xls.Available at: http://www.ncqa.org/HEDISQualityMeasurement/HEDISMeasures/HEDIS 2011/HEDIS2011NDCLicense/HEDIS2011FinalNDCLists.aspx
Oral Anti-Platelet Therapy	Source: HEDIS 2011 NDC List. Table IVD-E.xls. Available at: http://www.ncqa.org/HEDISQualityMeasurement/HEDISMeasures/HEDIS 2011/HEDIS2011NDCLicense/HEDIS2011FinalNDCLists.aspx
Statin Therapy	68645026254, 68462019890, 68462019805, 68462019790, 68462019705, 68462019690, 68462019605, 68462019590, 68462019505, 68382007316, 68382007305, 68382007216, 68382007205, 68382007116, 68382007105, 68382007016, 68382007005, 68382006916, 68382006914, 68382006910, 68382006906, 68382006905, 68382006840, 68382006816, 68382006814, 68382006810, 68382006806, 68382006805, 68382006724, 68382006716, 68382006714, 68382006710, 68382006706, 68382006705, 68382006624, 68382006616, 68382006614, 68382006610, 68382006606, 68382006605, 68382006516, 68382006514, 68382006510, 68382006506, 68382006505, 68258915401, 68258912801, 68258900101, 68258601303, 68258600903, 68258600209, 68258600203, 68258600109, 68258600103, 68258600009, 68258600003, 68258105701, 68258104001, 68180048809, 68180048802, 68180048709, 68180048702, 68180048609, 68180048602, 68180048509, 68180048502, 68180048209, 68180048206, 68180048103, 68180048102, 68180048101, 68180048003, 68180048002, 68180048001, 68180047903, 68180047902, 68180047901, 68180047803, 68180047802, 68180047801, 68180046907, 68180046905, 68180046903, 68180046901, 68180046807, 68180046805, 68180046803, 68180046801, 68180046707, 68180046703, 68180046701, 68115083690, 68115083630, 68115080090, 68115077790, 68115077730,

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APPENDIX 20: ADJUSTED KAPLAN MEIER CURVES FOR DIABETES ACSC AND ALL ACSC HOSPITALIZATIONS IN 2009

Model 1: Adjusted for Beneficiary Demographic Characteristics, Severity of Diabetes and Comorbidities